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A SURVEY OF THE TECHNICAL NEEDS OF INDUSTRY AND IMPLICATIONS FOR CURRICULUM DEVELOPMENT, IN HIGHER EDUCATION.

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*VOCATIONAL EDUCATION, INDUSTRIAL EDUCATION, EDUCATIONAL NEEDS, JOB TRAINING, VOCATIONAL HIGH SCHOOLS, VOCATIONAL SCHOOLS, *CURRICULUM DEVELOPMENT, *INDUSTRIAL ARTS, INDUSTRY, *MANPOWER DEVELOPMENT, TRAINING, *SURVEYS, NATIONAL SURVEYS, QUESTIONNAIRES, DEKALB, ILLINOIS

THE MAJOR PURPOSE OF THIS STUDY WAS TO SURVEY AND IDENTIFY TECHNOLOGICAL MANPOWER NEEDS OF INDUSTRY AND TO RELATE THESE NEEDS TO CURRICULUM DEVELOPMENT IN HIGHER EDUCATION. A QUESTIONNAIRE SURVEY METHOD WAS EMPLOYED FOR THE INVESTIGATION. APPROXIMATELY 11,000 COMPANIES WERE SELECTED FOR SATURATION MAILINGS. THE STUDY RESULTS WERE BASED UPON QUESTIONNAIRE RETURNS OF ABOUT 10 PERCENT OF THE SAMPLE COMPANIES. THESE RETURNS MET SPECIFIED CRITERIA FOR ANALYSIS. THREE KINDS OF INFORMATION WERE REQUESTED--(1) GENERAL INFORMATION ABOUT THE COMPANY, (2) TECHNOLOGICAL CHARACTERISTICS OF THE COMPANY, AND (3) INFORMATION ABOUT THE TECHNOLOGICAL NEEDS OF THE COMPANY. THE REPORT INCLUDES GENERAL AND SPECIFIC FINDINGS RELATED TO A TOTAL OF 50 TECHNICIAN POSITIONS. CURRICULAR CONCLUSIONS WERE PRESENTED FOR--(1) CHEMICAL TECHNOLOGY, (2) METALS TECHNOLOGY, (3) ELECTRONICS TECHNOLOGY, (4) MECHANICAL TECHNOLOGY, AND (5) MISCELLANEOUS TECHNOLOGY. (JC)

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A SURVEY OF THE TECHNICAL NEEDS OF INDUSTRY

and

IMPLICATIONS FOR CURRICULUM DEVELOPMENT IN HIGHER EDUCATION

Cooperative Research Project No. S-298

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CHAPTER I

INTRODUCTION

Sweeping changes are taking place in American industry at an ever-accelerating pace. These changes have been brought about by new developments in science and technology. The impact of this rapid scientific and technological progress upon the institutions which must train industry's technological personnel has been twofold. Both the quantity and the quality of the technological personnel needed are changing, and the educational establishment has not kept up with these changing requirements.

The nature of the changes taking place in industry is such that the quantity of needed technological personnel is increasing rapidly. Many traditional skills and jobs are becoming obsolete, and in their place, new jobs are being created, requiring technically competent personnel. The quality of needed technological personnel is changing also. The devices, machinery, and processes in industry are being continually up-dated or completely replaced by more complex instrumentation and more sophisticated techniques which demand a greater degree of technical competence and often new technical skills.

A deliberate and systematic effort must be made to keep pace and even anticipate the increased educational demands of the changing industrial world. This requires a new level of industrial-educational dialogue. Educators and industry en masse must work closely in order to understand and evaluate the developing needs and problems in the area of industrial technology. Only then will these needs and problems of the work world find their translation in educational programs.

Purpose

The objective of this study was to survey and identify the technological manpower needs of industry and to relate those needs to curriculum development in higher education. An attempt was made to determine not only the number of technicians needed by industry, but also the specific types of technicians and the talents which they should possess. The results would provide the university and industrial communities with a more accurate and organized source of information on manpower educational needs than has existed in the past and thus provide data with which more reliable, long-range planning may be done.

A secondary objective was to stimulate and to provide a basis for further research in this area. The study represents an attempt to call attention to a growing need for technological education based upon an understanding of the needs of industry. It is hoped that other investigations will follow, utilizing the information provided concerning the variables which must be considered.

Related Views

A careful examination of the literature and views held with reference to the technological needs of industry and the parallel curricular patterns in higher education has revealed no precise national pattern. The studies that have been completed appear to deal primarily with local needs and issues and almost entirely in terms of high school programs and the vocational function which the community college serves. Varying views have been provided reflecting industrial manpower needs and employment opportunities. Clarification of the technician's identity and industrial role has also been of some concern.

The contemporary image of the technician appears to be changing from that of an equipment specialist to what may be termed a technologist, that is, one who is essentially an applied functionary with a science background in an operational industrial setting. The development of engineering science with emphasis on the theoretical setting appears to be contributing to new supportive needs of a technological and operational character in industry.

Minimal agreement is often lacking within higher education, or between education and industry, on what constitutes effective approaches to programming technological education and training. From the current vantage point, one is led to believe that (1) a more precise characterization of the technician (technologist) is needed in terms of areas of work and his responsibilities, and (2) course-curricular patterns need further development to prepare the technician (technologist) of the future.

Methodology

The questionnaire survey method was considered most appropriate for this investigation. This method is especially useful in investigations for which there is not sufficient background material available to permit identification of the relevant variables. In the more formal methods of investigation, the identification and control of the relevant variables is essential for validity. Those methods have the advantages of being the most sensitive and definitive. Informal methods, such as that selected for this investigation, are more exploratory and descriptive. While not as sensitive, they allow the investigator more freedom to explore a large number of relevant variables and to describe their relationships to the problem.

It was recognized that this method of investigation lacked full control in the selection of the sample. Even though utmost care was exercised concerning the selection of companies to whom the questionnaire was sent, it was acknowledged that not all of those companies would cooperate by returning the completed questionnaire. Therefore, the sample would be some undetermined fraction of all the chosen companies, and it would not be a simple, random sampling. This selectivity allows some bias to enter into the sampling process.

Because of this lack of control in obtaining the sample, it was first necessary in this kind of study to identify the sample finally obtained. Stated more simply, it is necessary to determine who the sample subjects were. Proper interpretation of the results is contingent upon understanding the nature of the sample. Therefore, the questionnaire designed for the present study included items which would provide information about the nature of the responding companies.

Secondly, it was recognized that the questionnaire survey method lacks complete control in obtaining the data. In this study, each respondent was requested to record his own responses according to the instructions provided. As a result, three kinds of problems could arise. The first was that the subjects might not understand which information was being requested. Error might enter in when some respondents would choose not to read the instructions carefully. Even when the instructions were carefully read, it would be unlikely that all of the respondents would interpret them in precisely the same manner as the investigators had intended them. Another problem in obtaining data was that the respondents might give incorrect information. They might have been misinformed, or they might not have had current information available to them. The final problem in obtaining data was that some respondents might not complete the whole questionnaire. They might omit items because of an oversight, or because they were unable to provide the requested information, or because they simply did not wish to spend any more time with it.

These disadvantages may be minimized, but it was recognized as unlikely that they could be completely eliminated. To avoid misinterpretation, the study sought to provide instructions that were stated explicitly. Also, equivocal terms were defined precisely. Where possible, steps were taken to assure that the respondents were qualified to provide the desired information. The most that could be done, to this end, was to ask the respondent to seek the assistance of qualified persons in his organization whenever he did not feel sufficiently qualified himself. The questionnaire was kept as short as possible within the scope of the study. It was felt that even more important than length, was the design of the questionnaire. Hence, it was organized so that the respondents could simply indicate their responses by a number or check mark, and as much continuity as possible was provided from one item to the next.

It was recognized that there are also limitations with regard to the analysis and conclusions of this type of investigation. The lack of precision in obtaining questionnaire data results in some unknown degree of error. The investigators were generally unable to justify using the more powerful inferential statistics, and thus the analysis was limited to descriptive statistics. Specific conclusions were made with caution, pending verification in a more formal manner. In this investigation, the appropriate statistics were decided to be means, medians, percentiles, and correlations.

It was felt that the questionnaire survey method had two important advantages. First, it was flexible. It did not require detailed and replicated foreknowledge in constructing the design of an investigation. This was important because, historically, very little data had been collected with regard to the problem of the present investigation. The flexibility of the questionnaire survey method also allowed a large number of variables to be explored. This was important because the purpose of the investigation was to explore a number of variables with regard to their relationships to the problem.

The second advantage of the questionnaire survey method was that it provided a relatively economical way to collect data from a large number of subjects and from widely scattered areas. This was important because it was desired that this investigation be carried out in such a way as to provide results which would be applicable for further research in any section of the country and in any area of the manufacturing industry. From its inception, this investigation was not visualized as an end in itself, but as a stimulus and basis for further research on the problem of the technological needs of industry.

Design of the Questionnaire

Before actually collecting the desired data, an appropriate questionnaire had to be designed. As background for this task, the relevant literature was reviewed, including the curricular offerings of many schools of higher education throughout the country which had two- or four-year technical programs. In addition, the Dictionary of Occupational Titles and Codes and industrial and professional organizations, such as the Chamber of Commerce, were used as resources. A trial questionnaire was developed and refined. This refinement was based upon a pilot study conducted with the cooperation of three Chambers of Commerce in northern Illinois, as well as professional and industrial organizations. The final form of the questionnaire appears as Appendix A in this report.

Inasmuch as the study was concerned with detailed knowledge of a company's function, it was required that each respondent answer the questions with reference to his local company only. This, it was felt, increased the accuracy of the responses and improved the feasibility for responding when the respondent was concerned only with the local company situation.

Three kinds of information were requested. The first five items requested general information about the company. In order that the nature of the sample could be identified, information was needed concerning (1) the company's industrial classification according to types of products, (2) its basic organization, (3) the gross dollar value of its industrial product(s), (4) the number of people employed, and (5) the number of workers involved in production. The next twelve items dealt with the technological characteristics of the company. This section requested both factual information, such as the number of technical personnel employed, and opinions held by the company on such aspects as preferences for certain kinds of training. The final items were designed to obtain information about the technological needs of the company. The respondents were asked to anticipate their future need for technicians, as well as provide information about specific training implicit in the industrial need.

The questionnaire provided for both objective and subjective responses. Most of the responses required simply writing in the proper number or checking the appropriate selection. However, there were several places where an opportunity for additions or comments was provided, should the respondent be so inclined.

In an effort to have the terms "Engineer" and "Technician" used and understood with the same meaning by all, definitions of these terms were provided at the beginning of the questionnaire. Traditional and historical definitions were not used verbatim, inasmuch as it was felt that these definitions held "built in" concepts from the past which were possibly not present in current thinking. The following definitions were developed for this study. Their preparation involved review and evaluation by industrial, professional, and educational personnel.

THE ENGINEER'S FUNCTION

> Those services dealing with consulting activities and the translation and application of science and mathematics to the technological problems in industry. These activities may be characterized as interpreting scientific content for practical usage.

THE TECHNICIAN'S FUNCTION

> Those activities dealing with the implementation of the engineering function into industrial reality. This would require a substantial degree of proficiency in the fields of mathematics and science, and a familiarity with the potentials of industrial processes. The technician's work role is either one of liaison between engineering and production, or one of evaluating the control function of production.

The intent of these definitions was that the concepts expressed would be directly related to each other.

Distribution of the Questionnaire

Six zones of the United States were chosen for purposes of distributing the questionnaire. The country was divided into three major areas (East Coast, Midwest, and West Coast). These areas were divided into six zones where it was felt that advances in the technologies have been made. Further, it was assumed that the states in the six zones were typical, and that, being typical, these states were representative of other states having industrial technologies not included in the study. The six zones are listed below along with the states included within each zone.

Zone 1 - New England
  Massachusetts
  Connecticut
  Maine
  Rhode Island
  New Hampshire
Zone 2 - New York - New Jersey
Zone 3 - Mid-Atlantic
  Maryland
  North Carolina
  Virginia
  Delaware
  District of Columbia
Zone 4 - Illinois
Zone 5 - Texas
Zone 6 - California

Manufacturing directories were obtained for these areas, and about 11,000 companies were randomly selected from the directory listings for purposes of saturation mailing. Copies of the questionnaire were sent to each of the selected companies during the first mailing, which was made in June, 1964. A second, follow-up, mailing was made in August, 1964.

Some of the questionnaires returned by the companies were only partially completed, so it was necessary to set up a criterion for determining which returns were sufficiently complete to be of value in the analysis. It was decided that any questionnaire which had more than half of the items completed would be considered a usable response. For the purpose of data processing, a deadline of November 1, 1964 was set for accepting returns. Thus, any questionnaire which was returned before that date with more than half of the items filled out, was used in the analysis. There were about 1,100 such returns. The exact figures are displayed in Figure 1. The

FIGURE 1: USABLE QUESTIONNAIRE RETURNS FROM GEOGRAPHICAL ZONES

Geographical Zone	No. of Selected Companies	Number of Usable Returns	Percentage of Usable Returns
1. New England	2,193	228	10.40
2. New York-New Jersey	2,003	141	7.04
3. Mid-Atlantic	2,146	138	6.43
4. Illinois	1,256	187	14.89
5. Texas	1,033	73	7.07
6. California	2,578	326	12.65
Total	11,209	1,093	9.75

individual companies represented by these returns are the sample companies upon which this study was based.

Seven completed questionnaires were returned after the November 1, 1964 deadline and were not included in the analysis of results. In addition, 339 insufficiently completed questionnaires and letters were received before the deadline. Most of these contained explanations of why the company had not completed the questionnaire. These insufficiently completed responses were classified according to the reasons given. The results of this classification are displayed in Figure 2.

Analysis of Responses

The questionnaires provided two kinds of data, objective-quantitative responses, and subjective-written-in responses. The objective responses were transferred to IBM cards and analyzed, using data processing equipment provided by the Northern Illinois University Computer Center. The analysis was limited to the use of descriptive statistics such as means, medians, percentages, and product-moment correlations.

Analysis of the subjective responses was begun by listing the responses as they appeared on the questionnaires. Three capable individuals were asked to provide independent summaries by classifying these responses according to concepts which appeared repeatedly among them. These three summaries were used to prepare a final summary of subjective responses for each question in which such responses appeared.

FIGURE 2: CLASSIFIED REASONS FOR INCOMPLETE RETURNS

Reason Given	Number of Returns	Percentage of Returns
1. Employ no engineers or technicians	62	18.3
2. Questionnaire doesn't apply	53	15.6
3. Haven't time or staff needed to complete	51	15.0
4. Requested information must be obtained from another location	44	13.0
5. Requested information is not available	34	10.0
6. Simple refusal	30	8.8
7. Not primarily concerned with manufacturing	21	6.2
8. Company ceased operation	17	5.0
9. No explanation given	13	3.8
10. Against policy to provide requested information	8	2.4
11. Company moved or merged with another	6	1.8
Total	339	100.0

CHAPTER II

FINDINGS

General Findings

Sample Characteristics

The first task in the analysis was to determine the nature of the sample. Only after identifying the nature of the responding companies could one understand the character of the data represented. The first five items on the questionnaire were designed to provide information about the general characteristics of the responding companies.

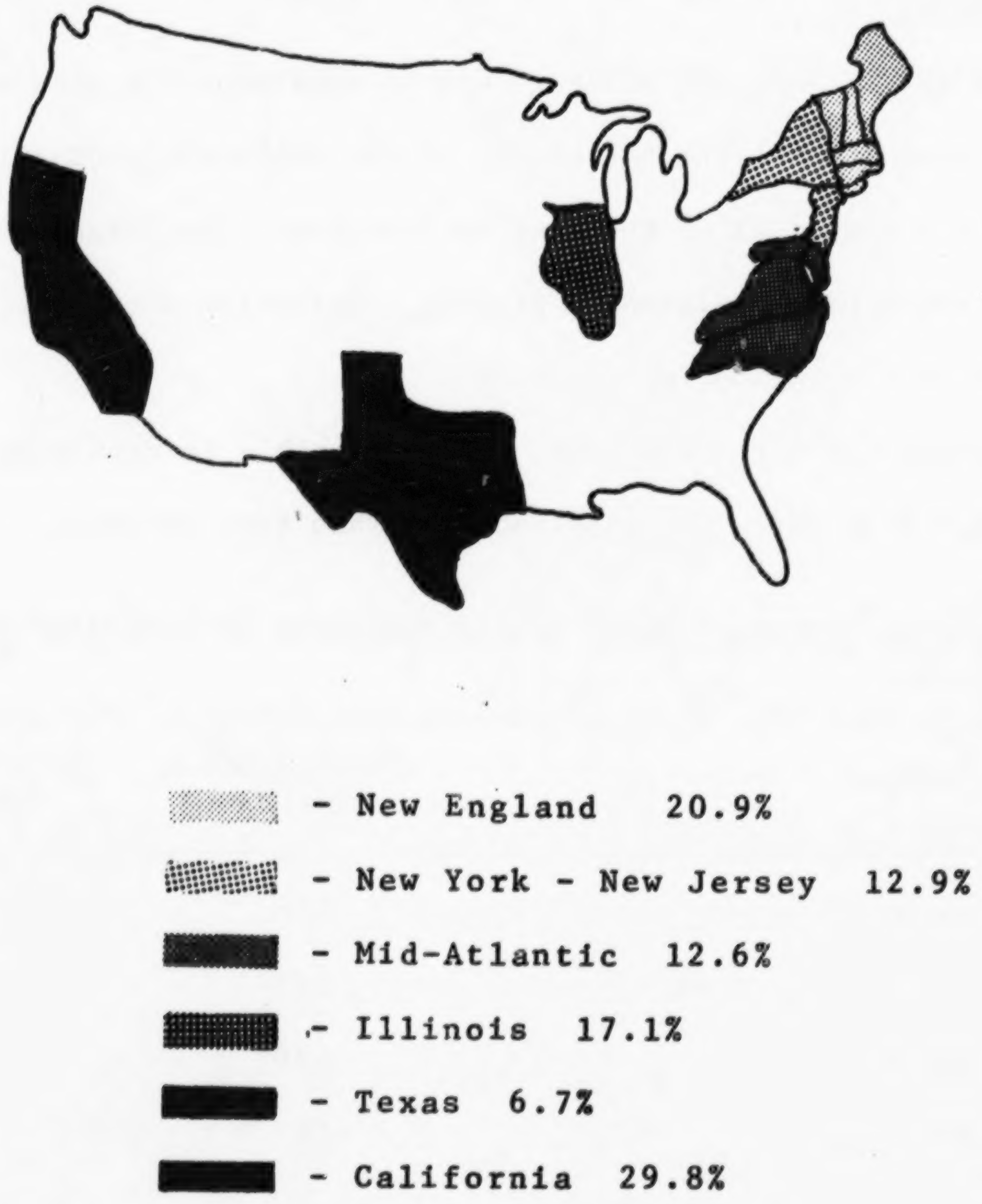
By coding the questionnaires, it was possible to determine the geographical zone from which the questionnaires had been returned. Figures 3

FIGURE 3: NUMERICAL DISTRIBUTION OF SAMPLE COMPANIES BY GEOGRAPHICAL ZONES

Area	Number of Companies	Percentage of Companies
1. New England	228	20.9
2. New York - New Jersey	141	12.9
3. Mid-Atlantic	138	12.6
4. Illinois	187	17.1
5. Texas	73	6.7
6. California	326	29.8
Total	1,093	100.0

and 4 display the number of questionnaires which were returned from each area and the percentage of the total sample (1,093 companies) which the numbers represent.

FIGURE 4: GEOGRAPHICAL DISTRIBUTION OF SAMPLE COMPANIES


- New England 20.9%
- New York - New Jersey 12.9%
- Mid-Atlantic 12.6%
- Illinois 17.1%
- Texas 6.7%
- California 29.8%

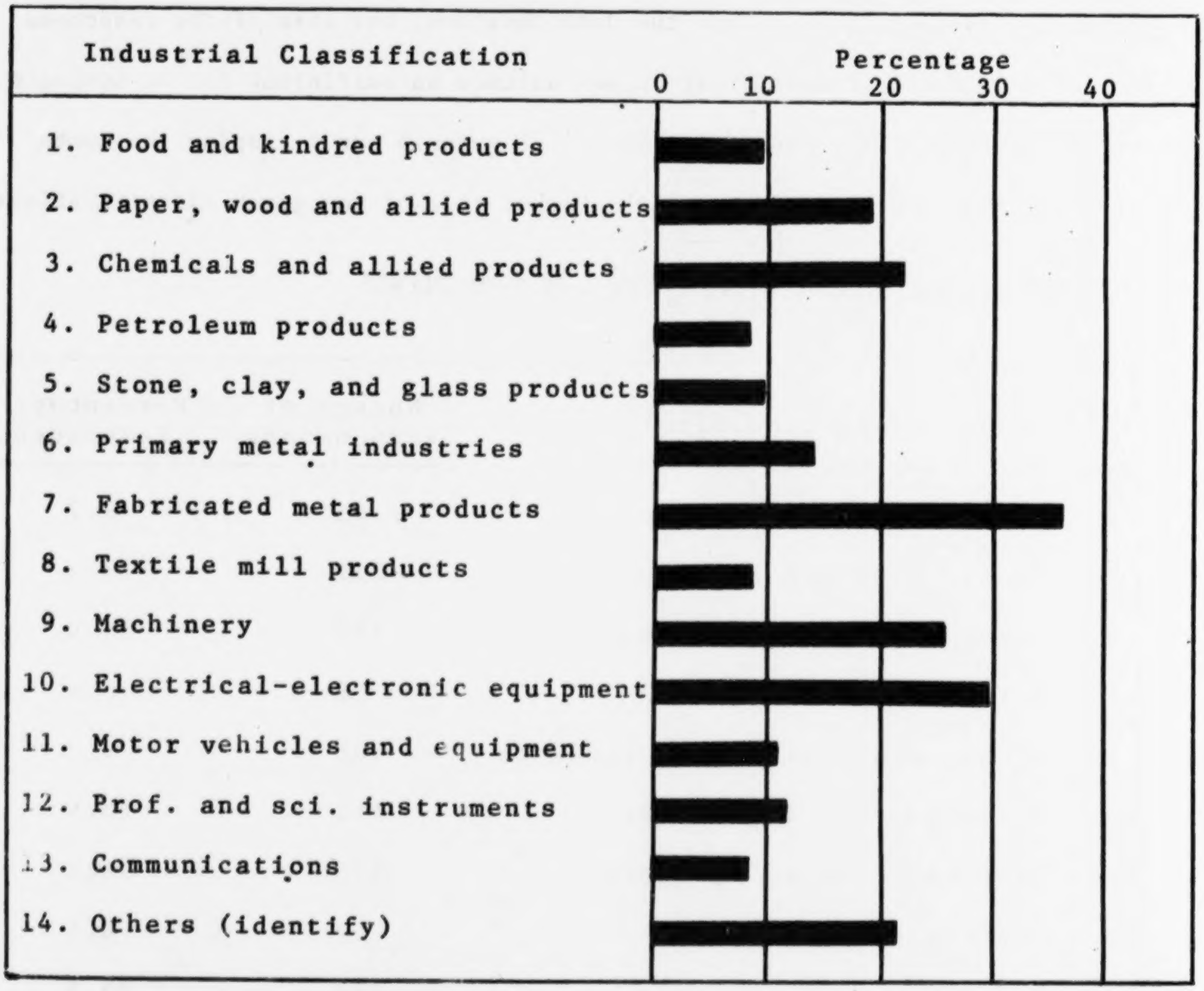
The Questionnaire

Item 1 listed 13 industrial product classifications, plus a 14th, undesignated, class. Respondents were asked to check those classifications that were of primary and major concern to their company locally. They were not limited to one selection. Hence, they checked all that applied. On the average, each company viewed itself as related to 2-1/3 of the industrial product classifications. From the data obtained, the size of the responses for each industrial classification was assumed as sufficient for an adequate representation of the industrial scene. Figures 5 and 6 display the number and percentage of respondents which checked each of the given classifications.

FIGURE 5: INDUSTRIAL CLASSIFICATIONS OF RESPONDENTS

Industrial Classification	Number of Respondents	Percentage of Respondents
1. Food and kindred products	101	9.2
2. Paper, wood and allied products	211	19.3
3. Chemicals and allied products	240	22.0
4. Petroleum products	92	8.4
5. Stone, clay, and glass products	106	9.7
6. Primary metal industries	151	13.8
7. Fabricated metal products	395	36.1
8. Textile mill products	94	8.6
9. Machinery	282	25.8
10. Electrical-electronic equipment	326	29.8
11. Motor vehicles and equipment	120	11.0
12. Professional and scientific instruments	128	11.7
13. Communications	96	8.8
14. Others (identify)	236	21.6

FIGURE 6: DISTRIBUTION BY CLASSIFICATION OF SAMPLE COMPANIES



Respondents who checked the 14th, undesignated classification, were those whose companies had industrial concerns which were not represented among the 13 given industrial product classifications. These respondents were asked to identify their company's other concerns. A total of 236, or 21.6% of the respondents did so. The following list contains the most frequently reported industrial concerns and the number of times each was reported beyond the regular classifications provided for in the questionnaire.

Plastics (27)

Aerospace (21)

Construction materials and equipment (19)

Rubber (18)

Graphic arts (18)

Coatings and finishes (10)

Wire and wire products (9)

Hydraulic and pneumatic equipment (9)

Leather (8)

Refrigeration and air conditioning (7)

Concrete products (7)

Agricultural equipment (5)

Furniture (5)

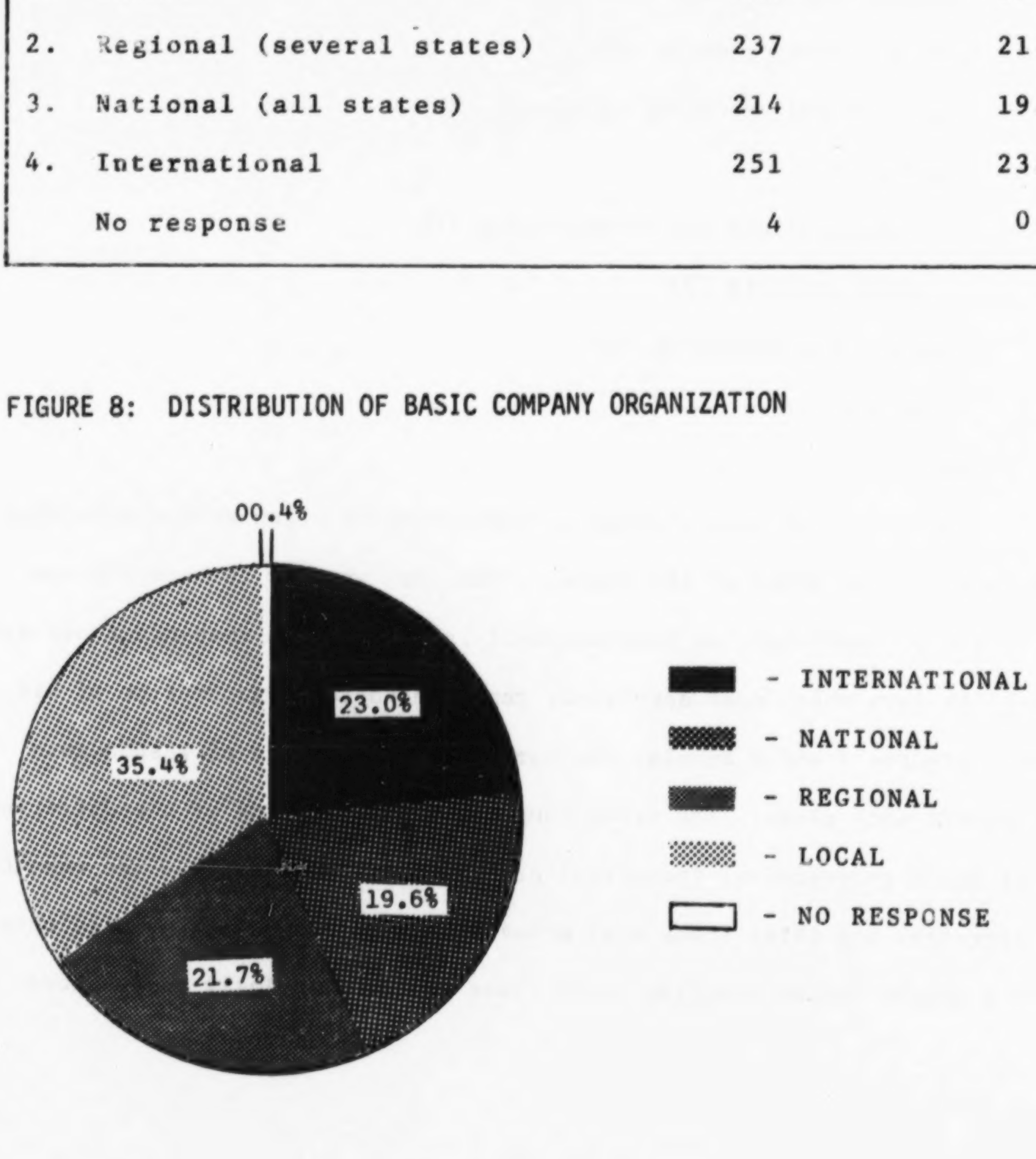
Optics (5)

Item 2 listed four classes of basic company organization according to the geographical scope of the company, that is, whether the company was local, regional, national, or international in scope. The respondent was asked to check the term which most accurately represented the organization of his company. Figures 7 and 8 display the number and percentage of respondents which checked each class. The study sought a broad sampling of the different types of basic geographical industrial organization in order that the results would represent the total industrial scene in the United States. While this was not a simple random sampling, each class was substantially represented.

FIGURE 7: BASIC COMPANY ORGANIZATION OF RESPONDENTS

Basic Organization	Number of Respondents	Percentage of Respondents
1. Local	387	35.4
2. Regional (several states)	237	21.7
3. National (all states)	214	19.6
4. International	251	23.0
No response	4	0.4

FIGURE 8: DISTRIBUTION OF BASIC COMPANY ORGANIZATION



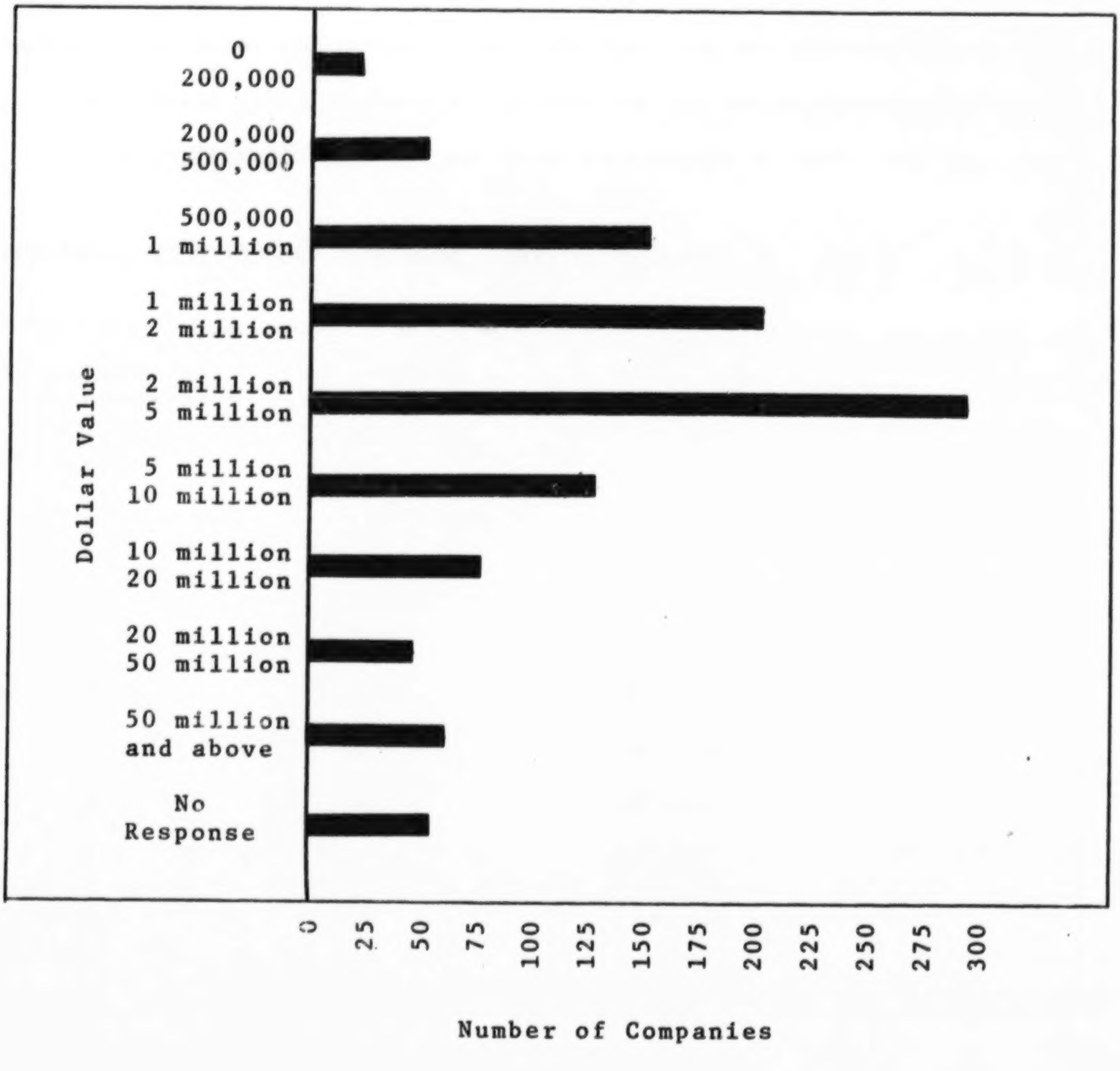
Item 3 asked for the approximate gross dollar value of the local plant's industrial product during the past business year. A scale of dollar value classifications was provided, and the respondent was asked to check the appropriate classification for his company. Figures 9 and 10 display the number and percentage of respondents which checked each classification.

FIGURE 9: FREQUENCY OF COMPANIES BY GROSS INDUSTRIAL PRODUCT CLASSIFICATIONS

	Dollar Value	Number of Respondents	Percentage of Respondents
1.	$ 0.00 - 200,000	23	2.1
2.	200,000 - 500,000	53	4.8
3.	500,000 - 1,000,000	153	14.0
4.	1,000,000 - 2,000,000	205	18.8
5.	2,000,000 - 5,000,000	290	26.5
6.	5,000,000 - 10,000,000	130	11.9
7.	10,000,000 - 20,000,000	76	7.0
8.	20,000,000 - 50,000,000	45	4.1
9.	50,000,000 and above	63	5.8
	No response	55	5.0

The study endeavored to provide representation for the broad financial spectrum of industry. The data obtained show that both the larger and smaller companies within this spectrum are well represented.

FIGURE 10: FREQUENCY DISTRIBUTION OF GROSS INDUSTRIAL PRODUCT CLASSIFICATIONS



The next few items asked for employment figures. As might be expected, a negative exponential distribution was obtained. In other words, there were a great many companies of small size, a lesser number of companies of medium size, and a still lesser number of companies of large size.

Describing the average company from a distribution of this sort, poses some special problems because the bulk of the companies do not tend toward the average or mean-sized company, but rather toward the smaller-sized company. The problem is that people habitually think in terms of a normal distribution in which the items tend toward some central value and there are relatively few items at either extreme on the scale. Thus the mean and the median are called measures of "central tendency." Complementary to the measures of central tendency are measures of "scatter," which describe the divergence of the items of value from the measures of "central tendency." The standard deviation is such a measure, and it has become customary to present standard deviations whenever means are used.

The employment data obtained in this study will be described in terms of means, medians, and standard deviations. It is important, therefore, to understand these statistics in terms of the negative exponential distribution described.

First of all, the means calculated from these kinds of data will be much larger than the medians. The reason for this is that the median represents the central company in size and is not affected by large deviations from the central value. The mean, on the other hand, is affected by extremes. Therefore, in a distribution which has a few extremely large companies, the mean for that distribution will be "inflated" by the size of those few companies. In this kind of distribution, the standard deviation will also be relatively large because of the divergence of the companies from the mean. The companies tend to be grouped at the lower employment figures rather than grouping around the mean employment figure. Thus, deviation from the mean is the rule rather than the exception.

To further illustrate the inflationary effect, suppose that we had a sample of 1,000 companies with a mean of 100 employees. If we added one more company, which had 100,000 employees, our mean for the 101 companies would be increased to 200, and our standard deviation would likely be increased several fold. Thus, one company of very large size doubled the size of our average or mean company. Yet, because one very large company accounted for one-half of the total employment in the sampling, it is not unreasonable that this one company had such a large effect upon the "average." The mean figure is, therefore, the best measure of central tendency for describing the "average" company and the distribution as a whole. On the other hand, if we wish to describe the "typical" company, the best measure would be the median. This statistical concept represents the central company within the distribution.

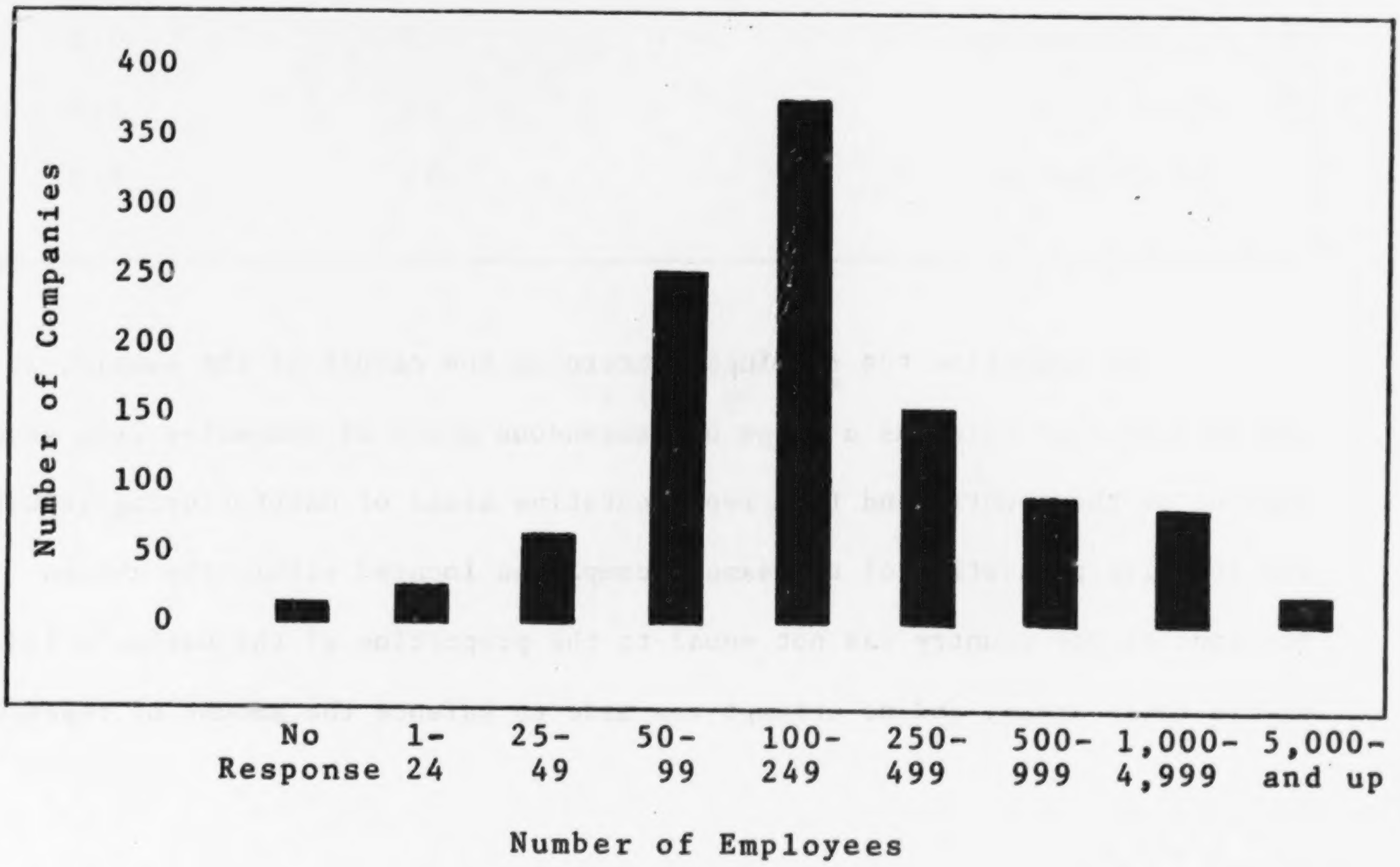
Item 4 asked for the total number of people employed by the respondent's company locally. The mean number of employees reported was 841 per company (average), with a standard deviation of 6,455, whereas the median number reported was 150 (typical). In other words, the sample companies had an average of 841 employees, but the typical or median company in the sample had 150 employees. The sizable standard deviation and the sizable difference between the mean and median were due to the distribution of the sample companies as shown in Figures 11 and 12. The bulk of the companies (typical) employed comparatively small numbers of people (300 or less), but there were a few which employed relatively large numbers.

Item 5 asked for the total number of workers involved in production (fabricating, assembly line, packaging, etc.), who were employed by the company locally. The mean number (average) was 499, with a standard deviation of 3,920.

FIGURE 11: FREQUENCY OF SAMPLE COMPANIES IN EMPLOYMENT CATEGORIES

Number of Employees	Number of Companies	Percentage of Companies
1. 1 - 24	27	2.5
2. 25 - 49	68	6.2
3. 50 - 99	252	23.1
4. 100 - 249	379	34.7
5. 250 - 499	156	14.3
6. 500 - 999	92	8.4
7. 1,000 - 4,999	86	7.9
8. 5,000 and up	22	2.0
9. No response	11	1.0

FIGURE 12: DISTRIBUTION OF SAMPLE COMPANIES IN EMPLOYMENT CATEGORIES



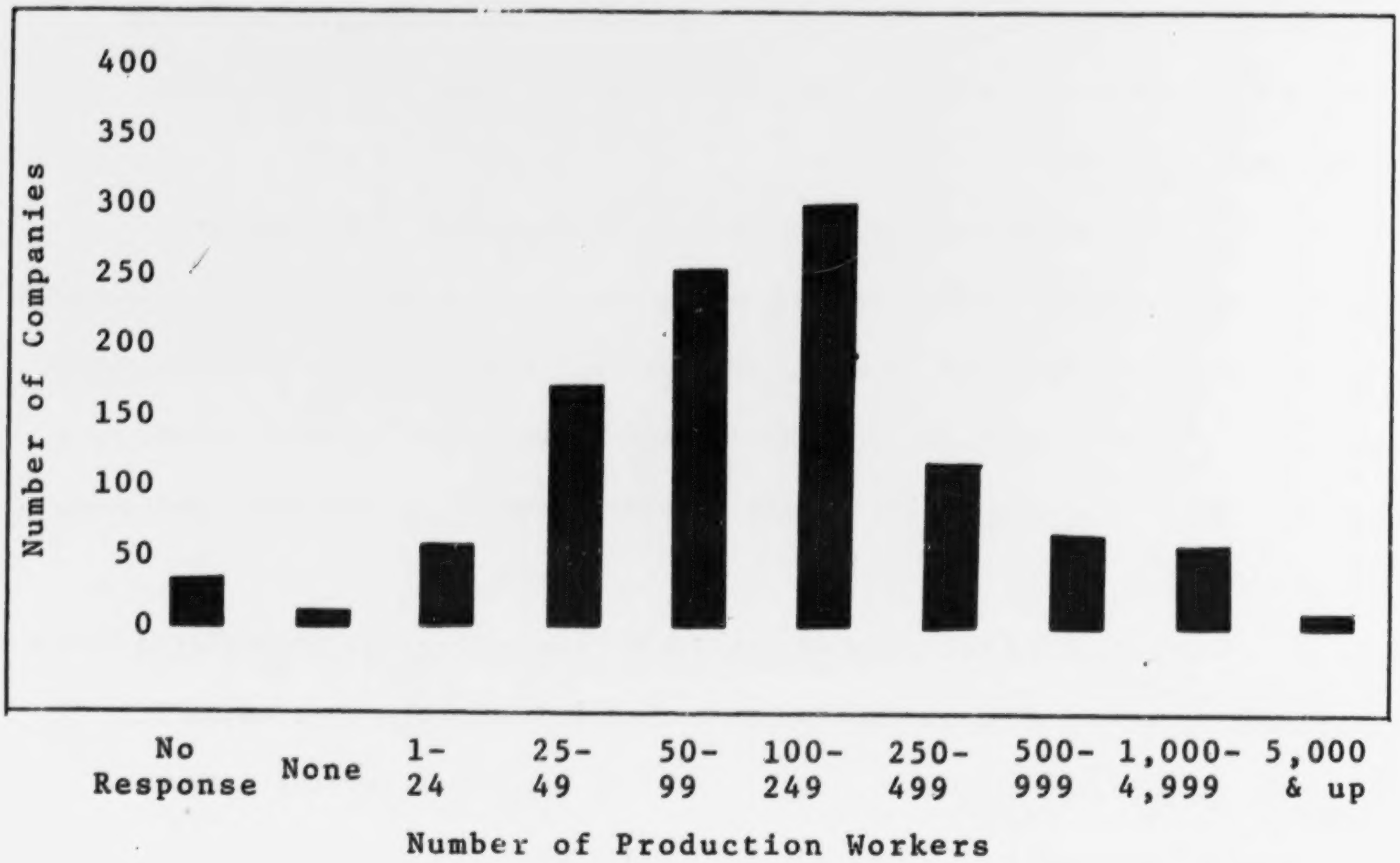
Here again, the few very large companies had an inflationary effect upon these statistics. The median number (typical) of production workers reported was 100. Figures 13 and 14 display the distribution of sample companies according to the number of production workers reported.

FIGURE 13: FREQUENCY OF SAMPLE COMPANIES BY PRODUCTION WORKERS CATEGORIES

Number of Production Workers	Number of Companies	Percentage of Companies
1. 1 - 24	68	6.2
2. 25 - 49	172	15.7
3. 50 - 99	256	23.4
4. 100 - 249	301	27.5
5. 250 - 499	118	10.8
6. 500 - 999	67	6.1
7. 1,000 - 4,999	58	5.3
8. 5,000 and up	9	0.8
9. None	11	1.0
No response	33	3.0

To summarize the findings concerning the nature of the sample, it can be said that this was a large neterogeneous group of companies from several regions of the country and from representative areas of manufacturing industry. The relative proportion of the sample companies located within the chosen sections of the country was not equal to the proportion of the nation's industry within those areas, and no attempt was made to balance the amount of representation

FIGURE 14: DISTRIBUTION OF FREQUENCY BY PRODUCTION WORKERS CATEGORIES



between sections of the country. However, the distribution of the sample companies according to types of industry, basic organization, dollar value of industrial products, and employment figures was found to be typical and assumed to be reasonable and acceptable for this study. The very small company was not as well represented as the larger companies, but this would be expected because, as the study indicated, few of the very small companies employed technical personnel.

Technological Characteristics

The second aspect of the study, items 6 through 17, was to characterize the sample companies with regard to their use of technological personnel. More specifically, this section concerned itself with the identification, number, functions, qualifications, and training of technological personnel in the sample companies. The responses requested were mostly objective in character, but there were also some subjective responses requested.

Item 6 asked for the total number of engineers (licensed or possessing a Bachelor of Engineering degree or more) employed by the respondent's company locally. The mean (average) number reported as 52.18, with a standard deviation of 458. Again, there are apparent inflationary effects caused by a few very large companies. The median (typical) number of engineers per company was 2-1/2.

Item 7 asked how many of the local company's total engineering force were serving a true engineering function as defined in the questionnaire. The respondents reported a mean (average) of 41.02 engineers serving a true engineering function full time, and 6.95 part time.

Item 8 asked how many of the total engineering force were serving a technician's function as defined by the questionnaire. The respondents reported a mean (average) of 8.07 engineers per company serving a technician's function full time, and 2.19 part time.

Item 9 asked for the total number of technicians as defined in the questionnaire, which were currently employed in the respondent's local plant. The mean (average) number of technicians reported as 29.08, with a standard deviation of 242. The median (typical) was 3.

Item 10 asked how many technicians (technicians having a high school or post-high school training but not a bachelor's degree) in the local company were serving a true technician's function as defined in the questionnaire. The respondents reported a mean of 23.72 technicians per company serving a true technician's function on a full-time basis, and 2.49 technicians on part-time. This would indicate that approximately 82% of the technician labor force serves a true technician's function.

Item 11 asked how many of the technicians were serving an engineering function as defined in the questionnaire. The respondents reported a mean of 1.10 technicians per company serving an engineering function full-time, and 0.65 serving part-time.

Some observations about the technological characteristics of the sample companies are appropriate at this point. First, the mean number of engineers reported per company (52.18) was substantially larger than the number of technicians (29.08), and yet this was not true of the corresponding medians (2-1/2 and 3). The reason for this is that the means were inflated by a small number of relatively large companies. Thus, they tended to be more descriptive of those large companies than they were of the more "typical" companies or companies of the size more frequently observed. The median is, therefore, the better measure of central tendency for describing the "typical" company (when the frame of reference is the distribution of sample companies). The mean, on the other hand, provides a more accurate measure of central tendency for describing the industrial sample as a whole (when the frame of reference is the distribution of all employees, engineers, or technicians employed by the sample companies).

Industry as a whole cannot be generally characterized by the concept of the "typical" company multiplied by the number of companies in industry. While this may appear at first glance to be a contradiction, there are a few atypical companies that are so large that they account for a large part of the total industrial employment. A later section of this report which deals with company size presents data indicating that, while the large companies tended to report more engineers than technicians, the smaller companies tended to report more technicians than engineers. This accounts for the difference in the engineer-technician ratio as determined by the means and the medians. Most of the sample companies were small and tended to employ more technicians than engineers. However, the fewer large companies which tended to employ more engineers than technicians account for such a large proportion of the total employment that, for the industrial sample as a whole, there were more engineers than technicians.

Another observation that can be made is that a larger proportion of engineers were reported as serving technician's functions (about 16% to 20%) than technicians serving engineering functions (about 4% to 6%). A reason for engineers serving a technician's function could be the lack of adequate technicians with the necessary technological "know-how" developed during the last decade. Another possible reason is that there could be a tendency toward up-titling technicians, that is, providing them with higher status by designating them as engineers. Also, the semantic interpretation of the functions of the engineer may influence the engineer-technician ratio. Figure 15 displays the mean number of engineers and technicians per company reported as serving each of the given functions.

Technician Programs

Item 12 listed five levels of education, and the respondent was asked to indicate the number of technicians employed by the local company having each level of educational background.

FIGURE 15: MEAN NUMBER OF ENGINEERS AND TECHNICIANS PER COMPANY SERVING GIVEN FUNCTIONS

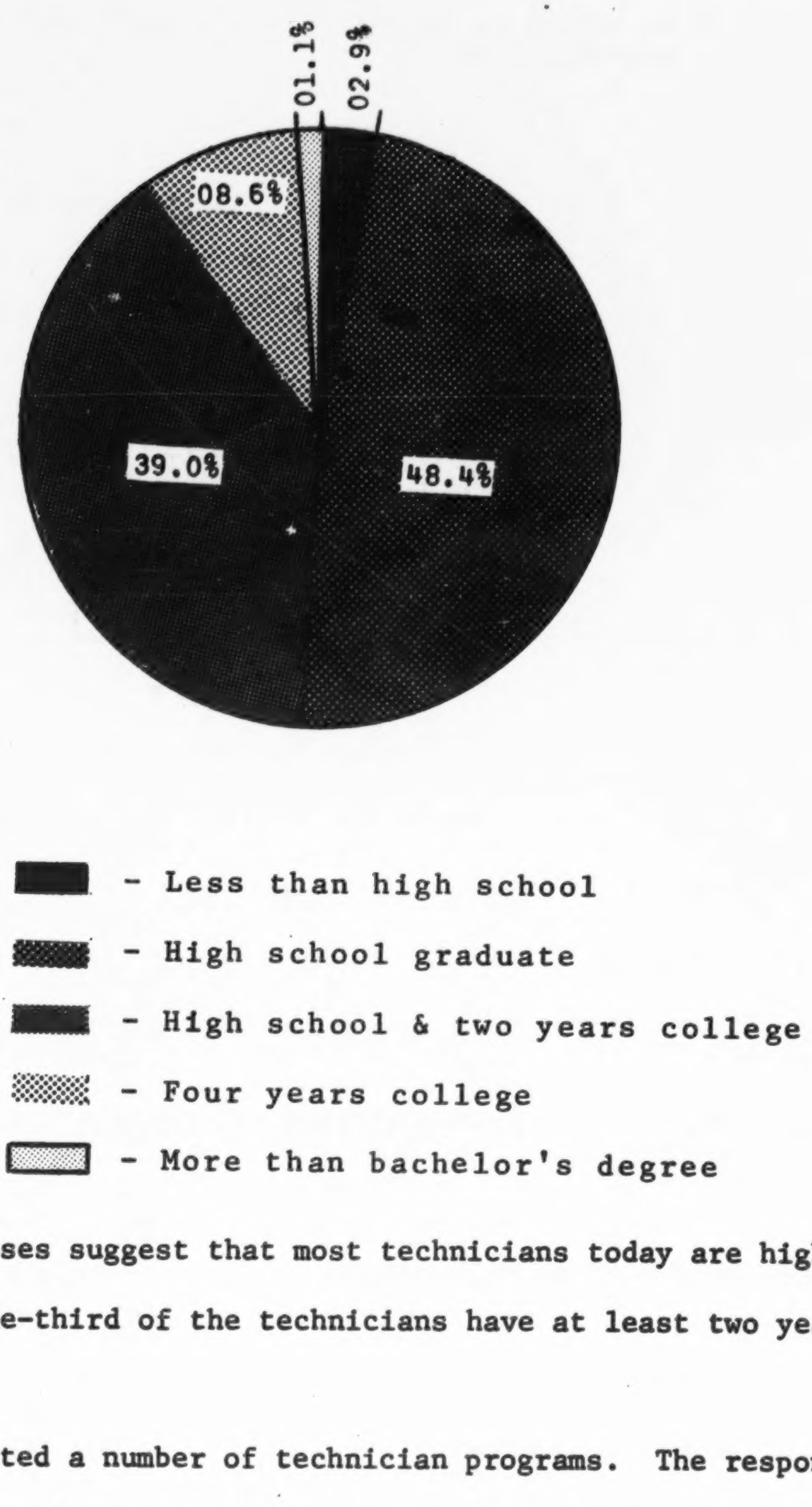
	Functions Served	
	Engineering Function	Technician's Function
Engineers	Full time 41.02 Part time 6.95	Full time 8.07 Part time 2.19
Technicians	Full time 1.10 Part time 0.65	Full time 23.72 Part time 2.49

Figures 16 and 17 display the mean number and percentages per company reported for each level. There was a great deal of variation in the educational backgrounds reported. Approximately one half of the technicians had as much as two years of college training. There are very few technicians currently who have less than a high school education or education beyond the baccalaureate

FIGURE 16: MEAN NUMBER OF TECHNICIANS PER COMPANY WITH GIVEN EDUCATIONAL BACKGROUNDS

Educational Background	Mean	Standard Deviation
1. Less than high school	0.73	7.63
2. High school graduate	12.09	125.22
3. High school & two years college	9.73	127.07
4. Four years college	2.14	26.75
5. More than bachelor's degree	0.29	6.08

FIGURE 17: DISTRIBUTION OF TECHNICIANS BY EDUCATIONAL BACKGROUNDS



degree. These responses suggest that most technicians today are high school graduates and over one-third of the technicians have at least two years of college.

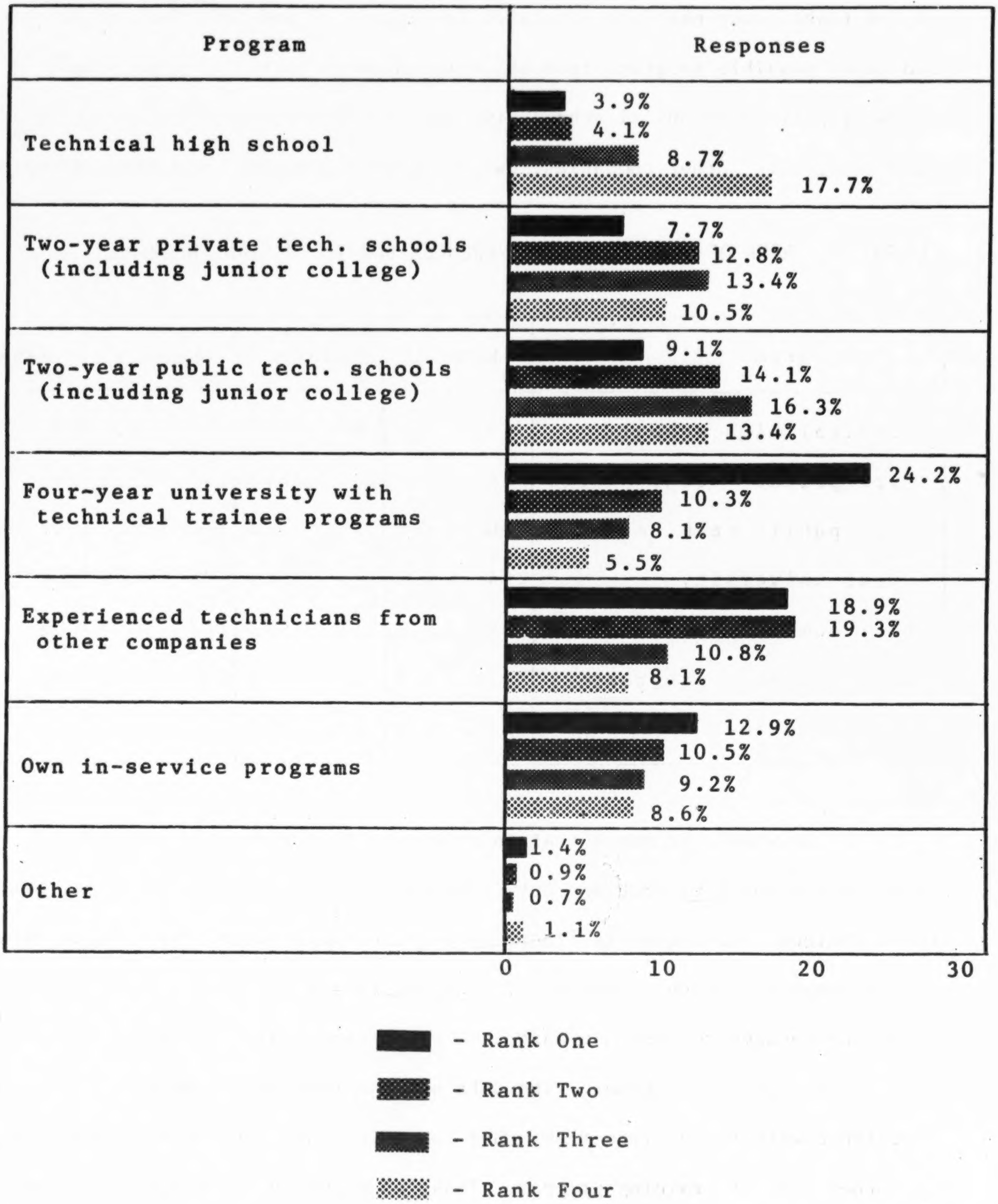
Item 13 listed a number of technician programs. The respondent was asked to identify in preferential order the top four programs which his company felt provided the most satisfactory technicians. Rank 1 was designated for the best program, rank 2 for the second best, and so on. The distribution of the ranked responses are displayed in Figures 18 and 19. The respondents had seven possible programs from which to choose: technical high school, two-year private technical school, two-year public technical school, four-year university, other companies, own in-service programs, and other programs.

FIGURE 18: RANK OF EDUCATIONAL PREFERENCES FOR TECHNICIAN PROGRAMS

Program	Rank 1 #	%	Rank 2 #	%	Rank 3 #	%	Rank 4 #	%
Technical high school	43	3.9	45	4.1	95	8.7	194	17.7
2 yr. private tech. school	84	7.7	140	12.8	147	13.4	115	10.5
2 yr. public tech. school	100	9.1	154	14.1	178	16.3	147	13.4
4 year university	264	24.2	113	10.3	88	8.1	60	5.5
Other companies	207	18.9	211	19.3	118	10.8	89	8.1
Own in-service programs	141	12.9	115	10.5	101	9.2	94	8.6
Other programs	15	1.4	10	0.9	8	0.7	12	1.1

It should be noted that in answering this item, the respondents selected the top four programs out of seven, being obliged to omit the remaining three choices. Consequently, there were differences in the percentages of the sample companies which responded with regard to any one of the programs listed. These percentages reflect, in part, the experience that the companies have had with these types of programs. The data suggest that more companies have had experience with technicians from other companies than with technicians from any other type of training program. Thus, even though other companies was

FIGURE 19: RANKED DISTRIBUTION OF EDUCATIONAL PREFERENCES FOR TECHNICIAN PROGRAMS



not the best preferred program, more companies selected it as one of the best four than any other program. On the other hand, fewer of the companies had their own in-service programs so that relatively few selected this program as one of the top four. While only one-third of the companies included their own in-service programs in the top four, those which did include it generally ranked it high.

The program most frequently selected as the most satisfactory was the four-year university with technical trainee programs. While relatively few companies ranked this program second, third, or fourth in order of preference, 24.2% of the sample companies ranked it first. Clearly, this was the program held in highest regard by the companies as a whole.

As a source of training, the program of securing experienced technicians from other companies was preferred by 18.9% of the companies. A slightly larger percentage (19.3%) ranked other companies second in order of preference; smaller percentages ranked it third and fourth.

The program preferred by 12.9% of the sample companies was their own in-service training program.

Two-year public technical schools were preferred above all other programs by 9.1% of the sample companies. This program was most frequently ranked third in order of preference with fewer companies ranking it second, fourth, and first, in that order.

Two-year private technical schools were preferred above all other programs by 7.7% of the sample companies. Like the public technical schools, this program was most frequently ranked third, followed by second, fourth, and first. These figures indicate that feelings toward public and private technical schools were similar and that they were generally not the company's first choice but were most frequently about third in order of preference.

The technical high school was selected as the preferred program by 3.9% of the companies. In general, this was the least preferred program. Most of the companies which included it in their ranking, ranked it fourth in preference.

In summation, the technical high school tended to be ranked relatively low. Two-year technical schools tended to be ranked in the third position. While other companies were the most frequently ranked source, it tended to be ranked in the second position. This suggests that, although this was not the best preferred program, it was the program most frequently familiar to the respondents. In-service programs tended to be preferred as a primary second choice, while four-year university programs tended most strongly to be ranked first.

The seventh classification in item 13 was titled "other programs." There were 45 respondents who replied to this category. In addition to ranking the other programs, they were asked to identify and to explain the nature of the programs. A predominance of military and in-service programs was identified. All but one of the respondents who referred to military training were located in New England or California. Also, it is important to note that all but one of the companies responding in this fashion dealt with some form of electronic equipment or professional and scientific equipment. It may be observed that military training is an important program in regard to electronic and professional equipment.

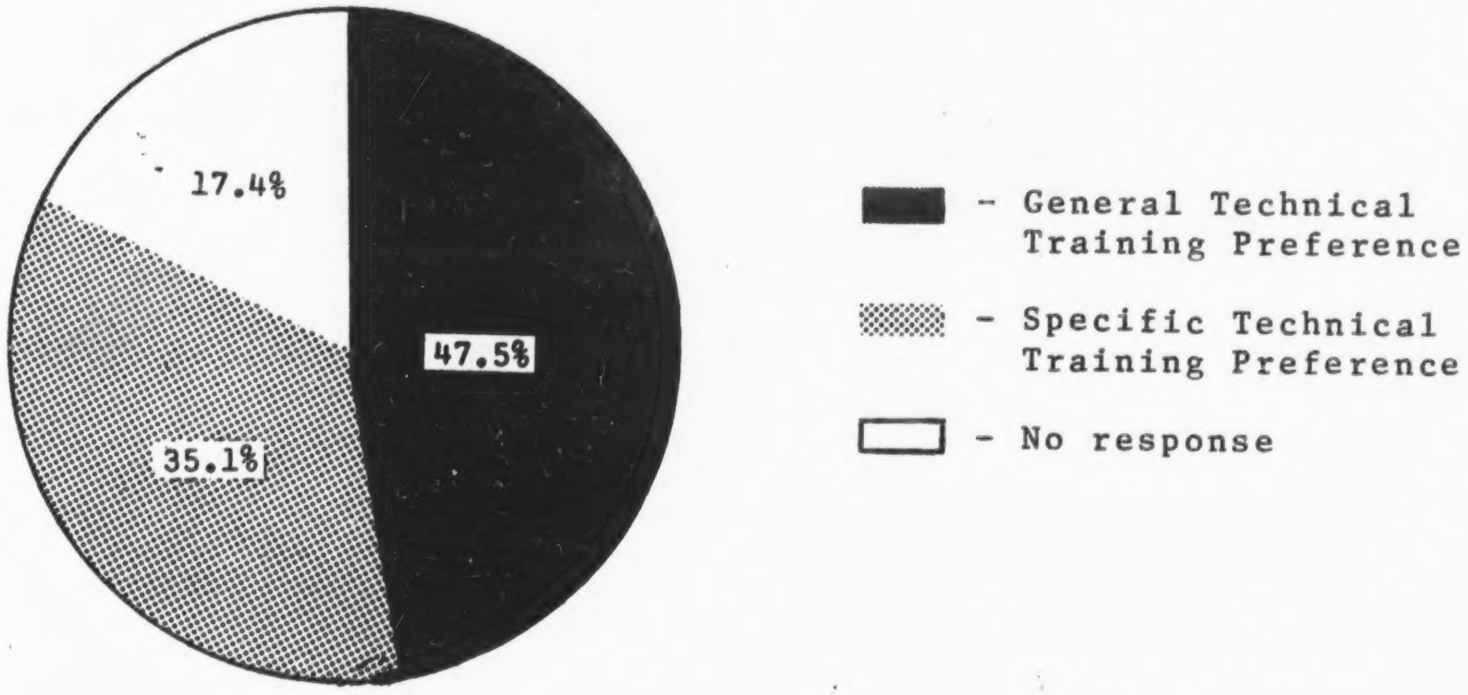
A sizable variety of different approaches was listed. Among them were the following:

1. Apprenticeship plus technical education beyond high school.
2. Courses offered by suppliers.

FIGURE 20: FREQUENCY OF TECHNICAL TRAINING PREFERENCES

	Preference	Number of Respondents	Percentage of Respondents
1.	General Technical Training	519	47.5
2.	Specific Technical Training	384	35.1
	No preference indicated	190	17.4

FIGURE 21: DISTRIBUTION OF SAMPLE COMPANIES BY TECHNICAL TRAINING PREFERENCES



that their preference depended upon the specific job opening. This opinion may account for the sizable percentage who made no response and presumably had no preference.

3. Cooperative work-study programs.

4. The use of university resources in addition to their own in-service training programs.

5. Field experience.

6. Training provided by outside engineering consultant firms.

7. Taking liberal arts graduates and providing multiple years of shop experience.

8. Correspondence schools.

9. Men with ability, regardless of training.

Item 14 asked the respondent to check the local company's preference with regard to background training when hiring technicians. General technical training and specific technical training characterized the choices of background preferences. Figures 20 and 21 display the frequencies of their responses.

An overwhelming number, 519 respondents, preferred general technical training to other types of training. This represented 47.5% of the respondents. There were 384 respondents who preferred specific technical training, representing 35.2% of the respondents reporting. There remained 190 respondents who had no preference, representing 17.4% of the respondents reporting.

This item included space for comments. The comments made by respondents preferring general technical training may be summed up by three statements.

(1) We have our own training program to teach specifics.
(2) Schools do not offer training in our specialty.
(3) People with general training are more flexible and trainable.

Most of the comments made by respondents preferring specific training indicated the area of training desired (predominantly chemical and electrical areas were listed), rather than the reason for their preference. Eight of the companies which did not respond to this item wrote in that they had no preference, or

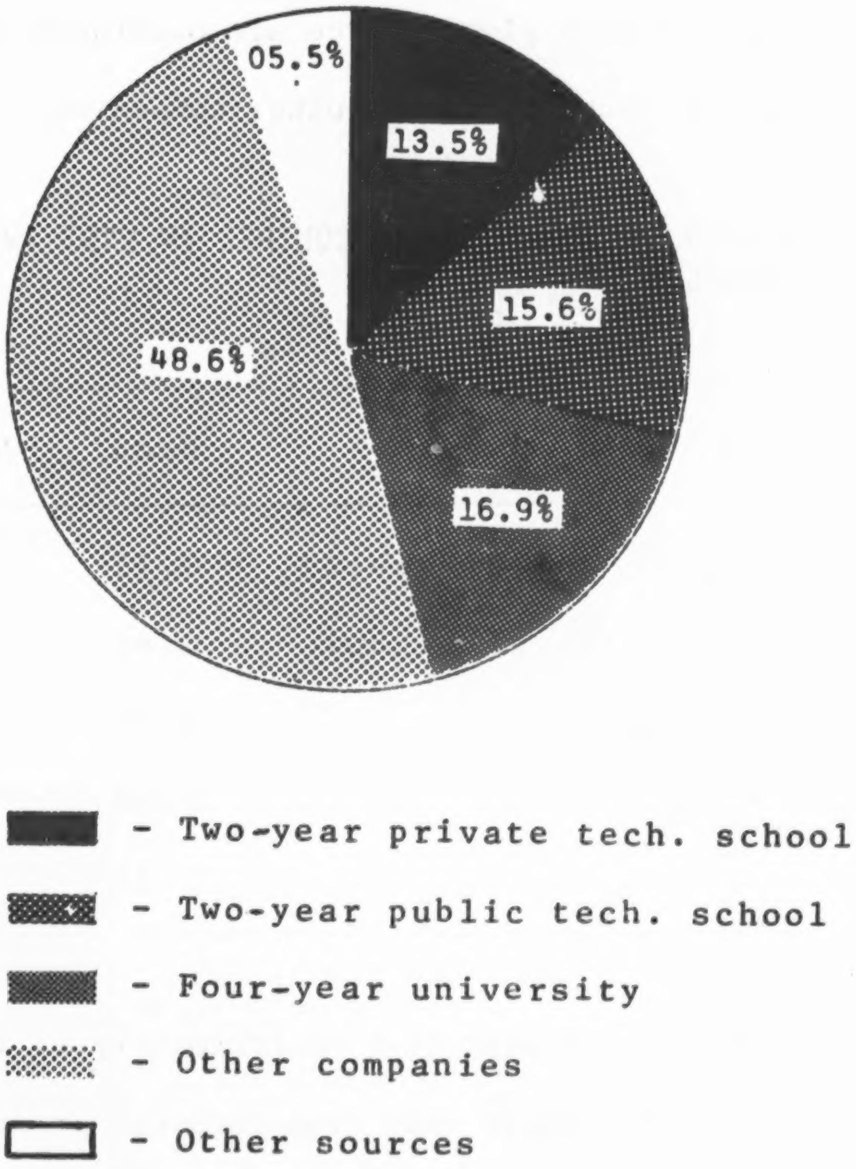
Item 15 asked the respondent to indicate how many technicians the company had acquired within the past two years from each of five given sources. The mean numbers reported per company are displayed in Figure 22, and the percentages acquired from each given source are displayed in Figure 23. The most frequent source for technicians was other companies.

FIGURE 22: MEAN NUMBER OF TECHNICIANS ACQUIRED IN LAST TWO YEARS FROM GIVEN SOURCES

Source	Mean	Standard Deviation
1. 2 year private technical school	0.75	8.86
2. 2 year public technical school	0.86	7.31
3. 4 year university	0.94	18.48
4. Other companies	2.69	20.40
5. Other sources	0.31	1.40

The respondents indicated that approximately 13.5% of the technicians acquired within the past two years came from two-year private technical schools, and an almost equal number, 15.6%, came from two-year public technical schools. Again, an almost equal number, 16.9%, came from four-year programs in higher education, that is, universities and colleges. The 16.9% in higher education actually represents programs that are directed toward the technological function in industry. Not surprising and of substantial magnitude is the finding that almost half of the total technicians obtained by the sample companies were acquired from other companies. Other courses not specifically identified were the sources for 5.5% of the technicians acquired. These were primarily high

FIGURE 23: DISTRIBUTION OF SOURCES OF TECHNICIANS ACQUIRED IN LAST TWO YEARS



school graduates with varying amounts of in-plant training which prepared them for the technician's function. Other courses not specifically identified were the following:

1. Their own training program
2. Armed services
3. Higher education
4. Employment services

5. Promotion from within
6. Apprenticeship programs
7. Self education

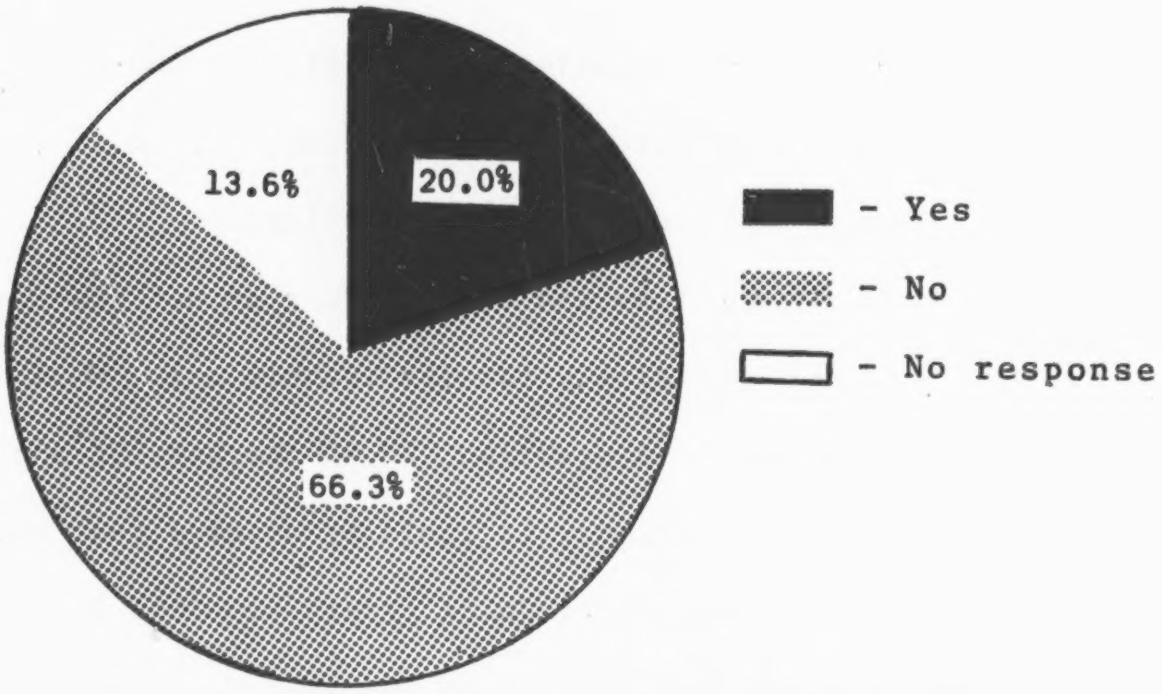
Of importance is the fact that other companies are the primary source of the technicians that are acquired. This parallels the finding in item 13 that industry places a high priority on actual training experience.

Item 16 asked the respondent to indicate whether or not the company had an in-plant training program exclusively for its technicians. While 13.6% of the respondents failed to answer this question, 20.0% checked YES and 66.3% checked NO. With relatively few exceptions, it could be assumed that those who did not respond did not have in-plant training programs. This item went on to ask how many technicians had been trained in the last two years. The respondents who indicated that they had an in-plant training program reported a mean of 3.98 trainees per company in the last two years, with a standard deviation of 7.02. Figures 24 and 25 display these results.

FIGURE 24: FREQUENCY OF AVAILABLE IN-PLANT TRAINING PROGRAMS FOR TECHNICIANS

Report	Number of Respondents	Percentage of Respondents	Mean Number Of Trainees
Had Program	219	20.0	3.98
Had no program	725	66.3	-
No response	149	13.6	-

FIGURE 25: DISTRIBUTION OF AVAILABLE IN-PLANT TRAINING PROGRAMS FOR TECHNICIANS



A related facet of the concern dealt with in item 16 suggested further probing of the data. The question raised was whether there was any substantial difference between companies with or without training programs as related to the technicians hired in the last two years. An analysis of the data uncovered the fact that companies with in-plant* training programs hired almost twice as many technicians in the last two years as companies without training programs. Companies with in-plant training programs hired an average of 9.16 technicians in the last two years, whereas companies without training programs each hired 5.59 technicians within the same period. Of further interest is that companies either with or without training programs hired more technicians from other companies than from other training sources, such as the two-year private or public technical schools, or universities.

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*In-plant training means utilizing only the training resources within the company structure.

The 219 respondents who indicated having in-plant training programs described briefly the programs which they reported in item 16. Their comments indicated that these were predominately informal, on-the-job training programs. Only a small fraction of the companies included formal instruction or formal apprenticeship programs.

Item 17 asked the respondent to indicate whether or not the company had an in-service* training program for its technicians in which the resources of neighboring educational institutions were used. While 14.5% of the respondents failed to answer this item, 16.9% checked YES and 68.5% checked NO. Here, also, it could be assumed that most companies who failed to respond at all, had no in-service training program. Respondents from companies with in-service programs were asked to indicate approximately how many employees were involved in this training in the past two years. A mean of 14.45 employees per company were reported, with a standard deviation of 89.26. These figures are displayed in Figures 26 and 27.

FIGURE 26: FREQUENCY OF AVAILABLE IN-SERVICE TRAINING PROGRAMS FOR TECHNICIANS

Report	Number of Respondents	Percentage of Respondents	Mean Number Of Employees
Had Program	185	16.9	14.45
Had no program	749	68.5	-
No response	159	14.5	-

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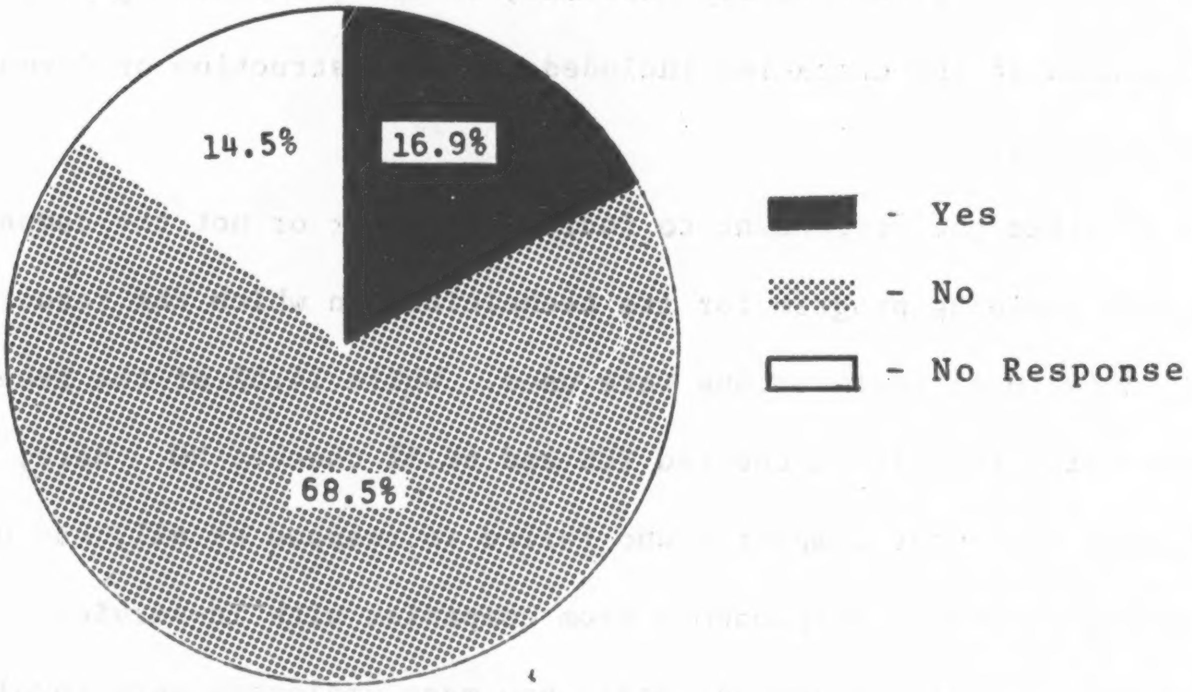
*In-service training means utilizing training resources within and outside of the company structure, such as the use of public and private educational institutions, professional seminars, and the like.

FIGURE 27: DISTRIBUTION OF AVAILABLE IN-SERVICE TRAINING PROGRAMS FOR TECHNICIANS



The in-service programs may be distinguished from the in-plant training programs in that they draw from educational resources not only within the company structure, but also draw from educational resources available outside of the company. These outside resources are usually provided by public and private institutions and universities.

The question was raised as to whether there were any substantial differences between the hiring practices of companies with and without in-service training programs. It was found that those companies which had in-service training programs secured about nine times as many technicians during the past two years. This finding parallels a similar finding with regard to companies which had in-service training programs. These observations reflect the need for technicians felt by some companies, as well as what they are doing about that need.

In addition, it may be noted that the companies with in-service training programs obtained almost four times as many technicians in the last two years as did the companies with in-plant training programs. There is also a sizable difference between the employment practices of those companies with in-service programs and those without in-service programs with regard to the employment sources they used. On the average, companies with in-service programs employed almost four technicians in the last two years. In contrast, those without in-service programs employed an average of only one-half of this number in the same period. This might be expected, inasmuch as the higher education oriented in-service program would be in closer communication with universities. This would provide the possibility of companies employing more people from this source.

Although comments were not requested in this item, 29 respondents did include comments. Most of these comments indicated that the companies encouraged their employees to continue their training at some local educational institution. Ten of these specifically stated that they had a tuitional aid program.

A number of observations may be made in summary of the data collected concerning technician programs. There was some discrepancy between the preferences expressed for various sources of technicians and the actual sources used. Almost half of the technicians reported as hired in the last two years were obtained from other companies. About one-third as many were obtained from the best preferred source, four-year universities. This suggests that there has been a good deal of inter-company competition for technicians and that universities have not provided the number of technicians desired by industry. The availability of technicians is far greater within the industrial complex than from university sources.

Only a small proportion of the companies had their own training program for technicians. However, those that did have such programs generally were quite satisfied with them. About one-tenth of all technicians in the survey reported had been involved in these in-plant training and in-service programs in the past two years.

There was a significant preference for general over specific technical training. The comments suggested that preference for the type of training depended upon the nature of the company's work, whether it employed technicians, and whether it had its own training programs. The companies which preferred general technical training required their technicians to perform a relatively large range of duties, or, where needed, provided specific training themselves. Those which preferred specific technical training generally required relatively repetitious duties within a limited area of their assignment. Of further interest is that 17% of the total respondents made no response to this question of training preferences, indicating that 83% held training as important, whether general or specific. Also, the large percentage who view training as important suggests the relative proportion of industry who knowledgeably support the curricular recommendations which are discussed later.

Technical Needs

Item 18 was designed to determine the future need for technicians in the five listed areas of technology: chemical, metals, electrical/electronics, mechanical, and others. This item was divided iinto two parts. The first section of the item asked for the approximate number of additional technicians having post-high school training but less than a bachelor's degree, which the company would need in the next five years. The second section of the item asked for the number of additional technicians possessing a bachelor's degree or more which would be needed in the next five years. The mean numbers reported per company are displayed in Figure 28.

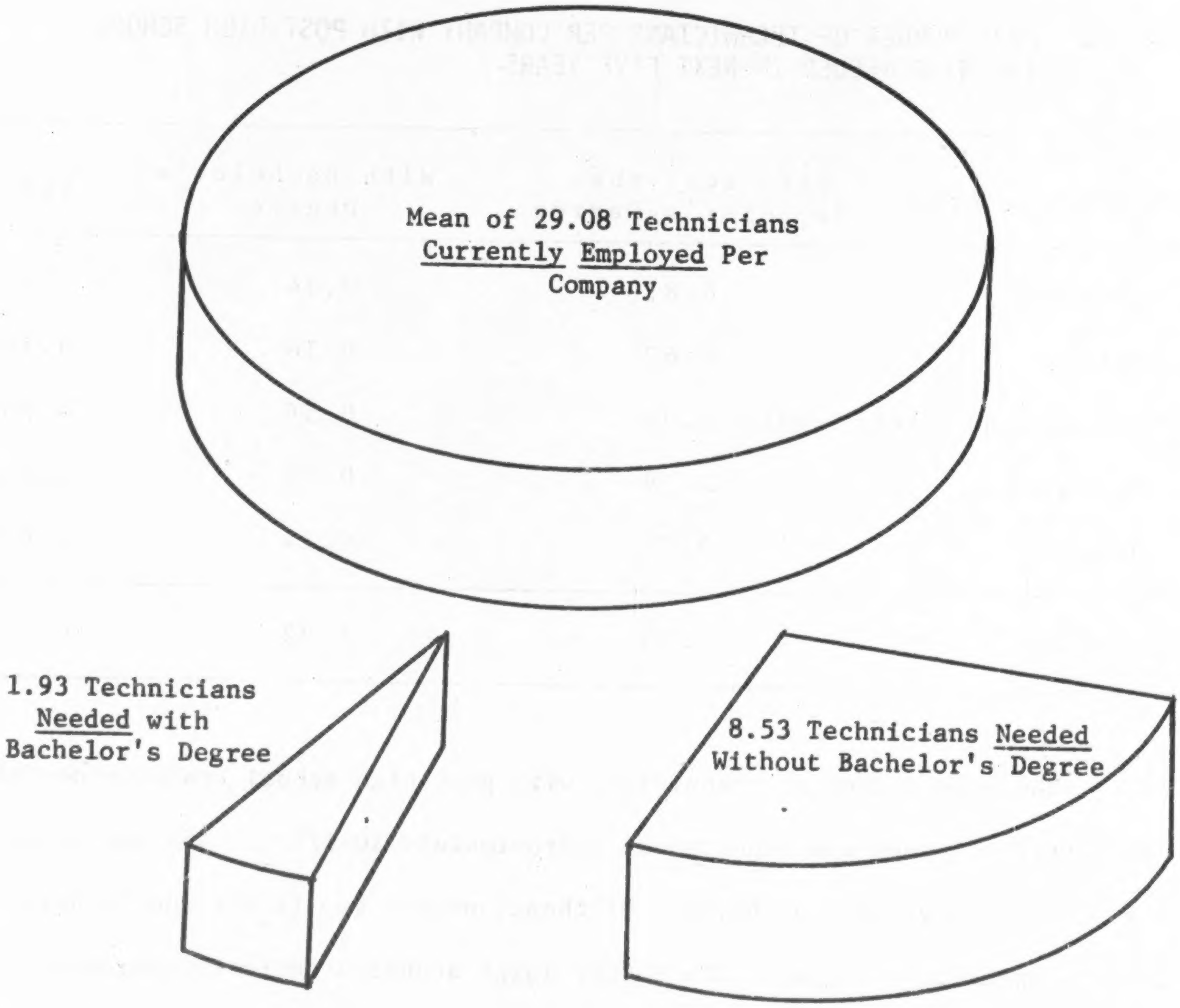
FIGURE 28: MEAN NUMBER OF TECHNICIANS PER COMPANY WITH POST-HIGH SCHOOL TRAINING NEEDED IN NEXT FIVE YEARS

Technical Area	With less than Bachelor's Degree	With Bachelor's Degree	Sum
1. Chemical	0.81	0.34	1.15
2. Metals	0.62	0.16	0.78
3. Electrical-Electronics	3.98	0.56	4.54
4. Mechanical	2.39	0.73	3.12
5. Others	0.73	0.14	0.87
Total	8.53	1.92	10.45

The mean number of technicians with post-high school training needed in the next five years was reported as approximately 10-1/2 (10.45) per company with a standard deviation of 60.97. Of these, nearly two (1.93) should have at least a bachelor's degree. The rather large standard deviation suggests that a substantial proportion of these technicians will be employed by large companies. The 10-1/2 technicians needed in the next five years represent a large increase (36%) over the total present employment of 29 technicians per company. Figure 29 displays these figures.

In general, 18.4% of the additional technicians needed should have a bachelor's degree or more. Currently, only 9.7% of the technicians were reported to have had as much as four years of college. Thus, the need for

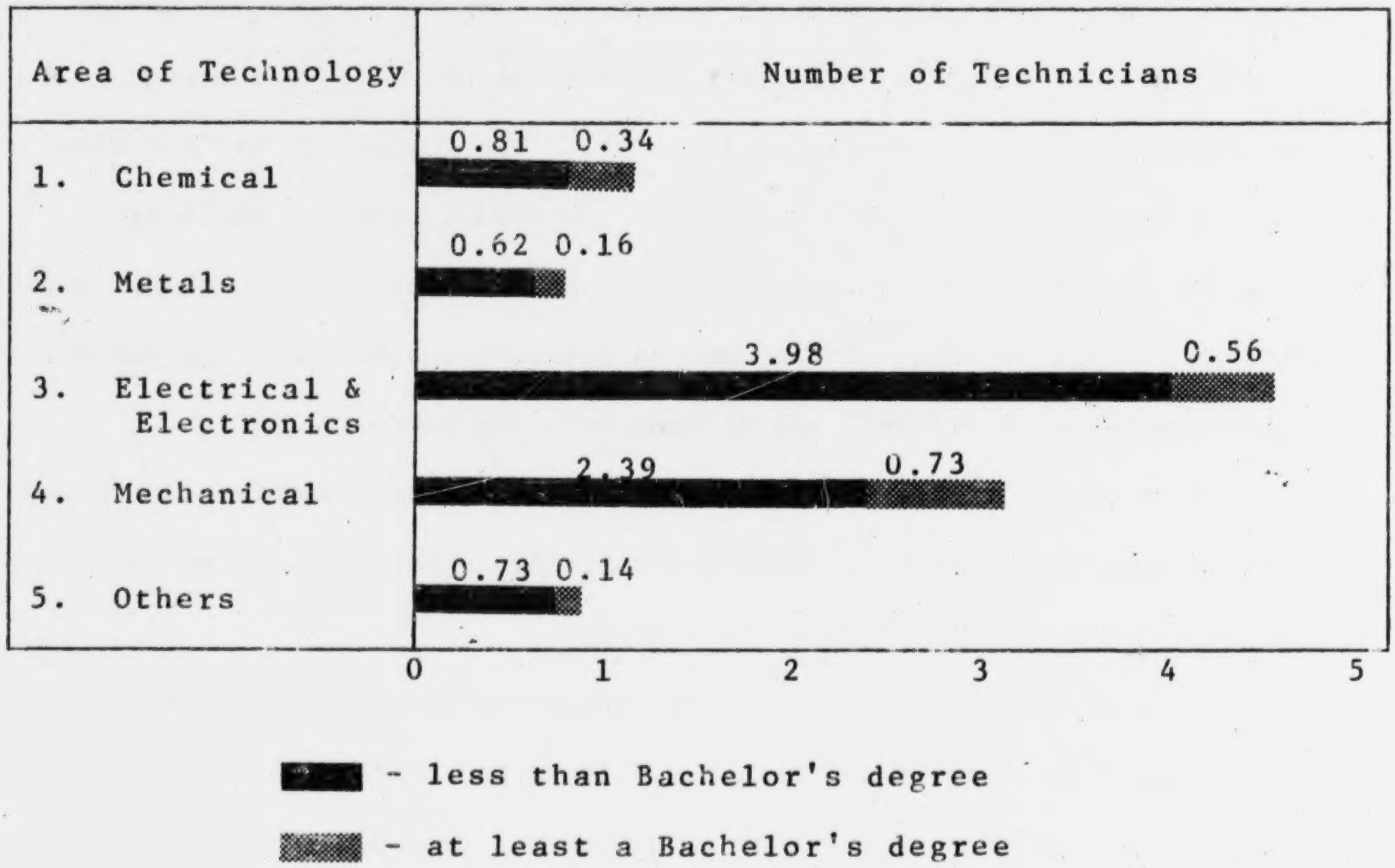
FIGURE 29: MEAN NUMBER OF TECHNICIANS CURRENTLY EMPLOYED AND NEEDED IN NEXT FIVE YEARS



technicians is particularly pressing for those who have completed their university training. Figure 30 displays the estimated number of technicians per company needed in each of the given areas of technology. This graph also shows the number which should have at least a bachelor's degree.

The area of technology which will require the greatest number of technicians in the next five years is that of electrical and electronics

FIGURE 30: ESTIMATED NUMBER OF TECHNICIANS NEEDED PER COMPANY IN NEXT FIVE YEARS



technology. Over 40% of the technicians required in the next five years were reported within this area of technology. That is, the companies represented by the sample reported that they will need about 4-1/2 electrical-electronics technicians per company in the next five years. About 30% of the technicians required in the next five years were reported in the area of mechanical technology. The sample companies estimated that they would need about three mechanical technicians per company in the next five years. About one technician per company will be needed in the next five years in the area of chemical technology and in the area of metals technology, and also in the remaining areas. Thus, about 10% of the technicians who will be required in the next five years were reported in each of these three areas of technology: chemical, metals, others.

The fifth classification in item 18 was undesignated. Those who used this classification were requested to specify the type of technician needed, and 221 respondents did so. Many different types of technicians were listed, and no one response appeared more than a few times. The following list contains some of the repeatedly mentioned responses: general industrial engineering, drafting and design, ceramics and clay, wood and furniture, paper, food, textiles, plastics and rubber, optics, biology and bacteriology, hydraulics and pneumatics, quality and production control, and methods and time study.

Item 19 dealt with the curricular views held by industry and subsequent recommended program patterns in technical training. These results are presented in a later section (Chapter III) of this report.

Item 20 asked for any additional suggestions or concerns which the respondent might be prompted to express. This was an effort to provide an open-ended opportunity to express views and concerns not provided for elsewhere in the questionnaire. The 210 respondents that availed themselves of this opportunity may be divided into two general groupings. Most of the comments dealt with the technical needs, and there were some comments about the survey effort.

A large number of respondents commented about the technical needs of their particular companies. Several said that they had little need for technicians because their companies were small. Several others said that they had little experience with technical personnel because their technical problems were handled by (1) distributors of materials and equipment, (2) a centralized engineering department serving a number of plants within the same company, or (3) an engineering consultant firm working on a contract basis. Such companies were of limited help in providing information desired.

A large number of responses indicated that some companies had difficulty in obtaining techical personnel. Further, others stated that the need for technical personnel "should accelerate markedly in the coming years." Clearly, there are not enough technicians available to meet the demand of industry, and the industrial demand is growing.

Concurrently, several respondents expressed a concern over the flux of technically trained personnel into other areas. For example, one wrote, "Our biggest problem has been to keep engineers and technicians in our business. We have lost several in recent years to sales-type jobs with other companies." There were also a number of respondents who said that their companies hired technicians "on the basis of ability to move into other departments." Thus, they viewed the technician's position often as a transitional situation, having almost selective qualities for preparing people for work in other areas, such as sales or supervision.

A large number of respondents commented upon specific training needs. Prominent among these responses were statements expressing a need for training in mathematics. Verbal and written English and the ability to communicate (thought structure) effectively were often mentioned. Others expressed concern for preparation in the basic sciences, humanities, business, economics, and many specific technical areas. Respondents likewise stated that industrial experience was an important part of the technical training program.

A small number of respondents expressed mixed feelings about the value of two-year technical training programs. While two respondents stated that graduates from such programs were satisfactory for their needs, others severely criticized the "end product" of such programs. One said, "This survey touches on one of the most critical problems in industry today. There are ample programs to train engineers; the prestige of an engineering profession draws candidates. The trade schools generally do not turn out quality technicians. The people drawn into trade school programs are not the most inventive or skilled." Other respondents made similar comments.

Another complaint repeatedly made concerning technical training was that it was not up-to-date. One respondent said, "Most technically trained personnel entering industry today, although generally well-versed in the 'classic' methods of design, control, analysis, etc., are woefully lacking in the knowledge and use of modern and up-to-date equipment and 'know-how' available to perform these functions."

Perhaps the most recurring observation which can be made concerning these responses is that their companies expected their needs for technical personnel to accelerate in the future. The following quotations illustrate this point:

> We have been using a higher percentage of technicians as time has gone on. We will continue this trend, particularly if the people have more training to increase the responsibilities to which they can be assigned.
>
> With new equipment becoming more and more complicated, automated, and 'technical,' it is absolutely necessary to have more technical training.

Other comments about the survey were explanations of why the companies were unable to provide some of the information requested. These explanations were usually (1) that the company lacked experience with technical personnel, (2) that the necessary records were not available, or (3) that the questionnaire was not applicable to the company. A few respondents disagreed with the stated definitions for "engineer" and "technician," and some said that the questionnaire, particularly item 19, was too long.

Summary

Figure 31 displays the employment figures per company reported by the sample companies as already discussed in this section of the report. The means and standard deviations have been rounded to the nearest unit.

FIGURE 31: STATISTICAL CHARACTERIZATION OF CURRENT EMPLOYMENT BY SAMPLE COMPANIES

Parameter	Median	Mean	*Standard Deviation
Number of Employees	150	841	6,455
Production Employees	100	499	3,920
Engineers	2 ½	52	458
Technicians	3	29	242
Technicians needed in 5 years	3 ½	10	61

*The sizable Standard Deviations are the result of the exponential distributions of the industrial populations.

The median employment figures have been used to describe an ideal, "typical company." The "typical company" had a total employment of 150. It employs two or three engineers and three technicians at the present time. It is noted that this "typical company" expects its need for technicians at least to double in the next five years. Specifically, it reported that it would need three or four additional tecnicians in five years.

Just as industry as a whole cannot be understood in terms of "typical companies," so the sample as a whole cannot be thought of as a proliferation of "typical companies." Statistically, this fact is expressed in Figure 31. But in concrete terms, it means that a relatively few extremely large companies account for an especially large proportion of the total employment within the sample. This is also true of industry as a whole, where a few companies have excessively large numbers of employees and, therefore, have considerable influence upon the total employment picture. The mean employment figures per company best represent this total picture. The "average company" in the sample is described in terms of arithmetic means. This "average company" has a total employment of 841, including 52 engineers and 29 technicians. The important statistic to note is that it reported a need for 10 additional technicians in the next five years. This is an increase of 36%. It may be concluded that, because the sample companies reported a need for 10 additional technicians per company in the next five years, 10 will be needed for similar companies throughout the country.

The distribution of the sample companies according to their employment figures, did not fit the "normal curve" but could best be described as following a negative exponential distribution. This kind of distribution is characteristic of the nation's industry in general. In other words, the largest number of companies was found in the smallest employment categories. Fewer companies were found to be intermediate in size, and very few were found to have an extremely large number of employees. Similar negative exponential distributions were obtained for the total number of production employees in the company, the number of engineers in the company, the number of technicians in the company, and the number of technicians which will be needed by the company in the next five years. As shown in Figure 32, the correlations between these figures were generally quite high, indicating that the companies with a larger number of employees support the need for larger numbers of technicians in the next five years.

FIGURE 32: MATRIX OF PRODUCT-MOMENT CORRELATION COEFFICIENTS OBTAINED FROM REPORTED EMPLOYMENT

Variables	Employees	Production Employees	Engineers	Technicians	Techs. Needed in 5 years
Employees		97.25	87.19	72.10	64.38
Production Employees	97.25		75.89	57.77	41.82
Engineers	87.19	75.89		90.36	69.83
Technicians	72.10	57.77	90.36		67.04
Techs. Needed in 5 years	64.38	41.82	69.83	67.04	

The coefficient of 90.36 obtained for the correlation of the number of engineers and technicians in the sample companies was particularly high. This finding suggests that the relationship of engineers to technicians in companies is especially interdependent and supportive. In addition, the correlation coefficient of 69.83 between the number of technicians needed and the number of engineers in the companies suggests that the need for technicians is substantially related to the engineering needs of the company. Thus the technician's function in industry is complementary to that of the engineer. The correlation coefficient of 67.04 between the number of technicians needed and the number of technicians employed by the companies was similarly high. Hence, it can be concluded that the need for technicians in the next five years is likewise related to the present use of technicians. Those companies who now use technicians expect to make further use of them in the future.

Comparing expressed comments made in item 20 with the factual data obtained in other items, an interpretable pattern of responses has emerged. There was a large number of comments stating that technicians were difficult to obtain and to retain, and that there was a great deal of inter-company competition for technical personnel within industry. These statements received support in the objective data. Item 13 indicated that other companies were not the most preferred source for technicians, yet item 15 showed that most of the technicians hired within the past two years were obtained from other companies. In other words, industry, while preferring one type of preparation, was actually hiring from another; that is, taking what they can get, not what they necessarily prefer. In a sense, they are resorting to a form of industrial-intellectual cannibalism.

One reason for this situation appeared to be that industry was not getting the number of university-trained technicians which it needed. Item 13 indicated that the university as a source was by far the best preferred program for technicians, but as shown in item 15, only a small percentage of technicians was hired from this source. This, without a doubt, was due to the limited numbers that were available. Comparing the results of items 12, 15, and 18 indicates that an increasing amount of emphasis is being placed upon university training for technicians. In the past two years, more technicians (15.6%) were hired from universities than ever before, and it was reported that, in the next five years, 18.4% of the technicians hired should possess a bachelor's degree. Thus, universities are not meeting the present demand, and this demand may be expected to accelerate in the future.

Another reason for the lack of qualified technicians was the movement of technicians (horizontal and vertical advancement) into other positions such as sales or supervision, in which there was more opportunity for upward mobility in the company, or into fields of more advanced technology. This movement tends to remove technicians "from the top," that is, the most desirable university-trained personnel.

To compensate for this condition, many companies tend to "up-title" their technicians. This was seen in the responses to item 8. Often, companies would give personnel the title and compensation of an engineer, but the responsibilities of a technician. Another way in which companies are handling this problem is to hire people for whom there would be a limited market and vertical advancement. As one respondent put it, "Selfishly we prefer limited training. Thus, we are not so apt to lose technicians to other companies."

A less immediate but more satisfactory solution would be for industry and education to work together to provide sufficient educational opportunities for adequate numbers of able young men, and then to give these people occupational status commensurate with their ability and degree of training. A few respondents did state that this kind of solution was needed. This position is certainly strongly supported by the data thus far presented.

Specific Findings

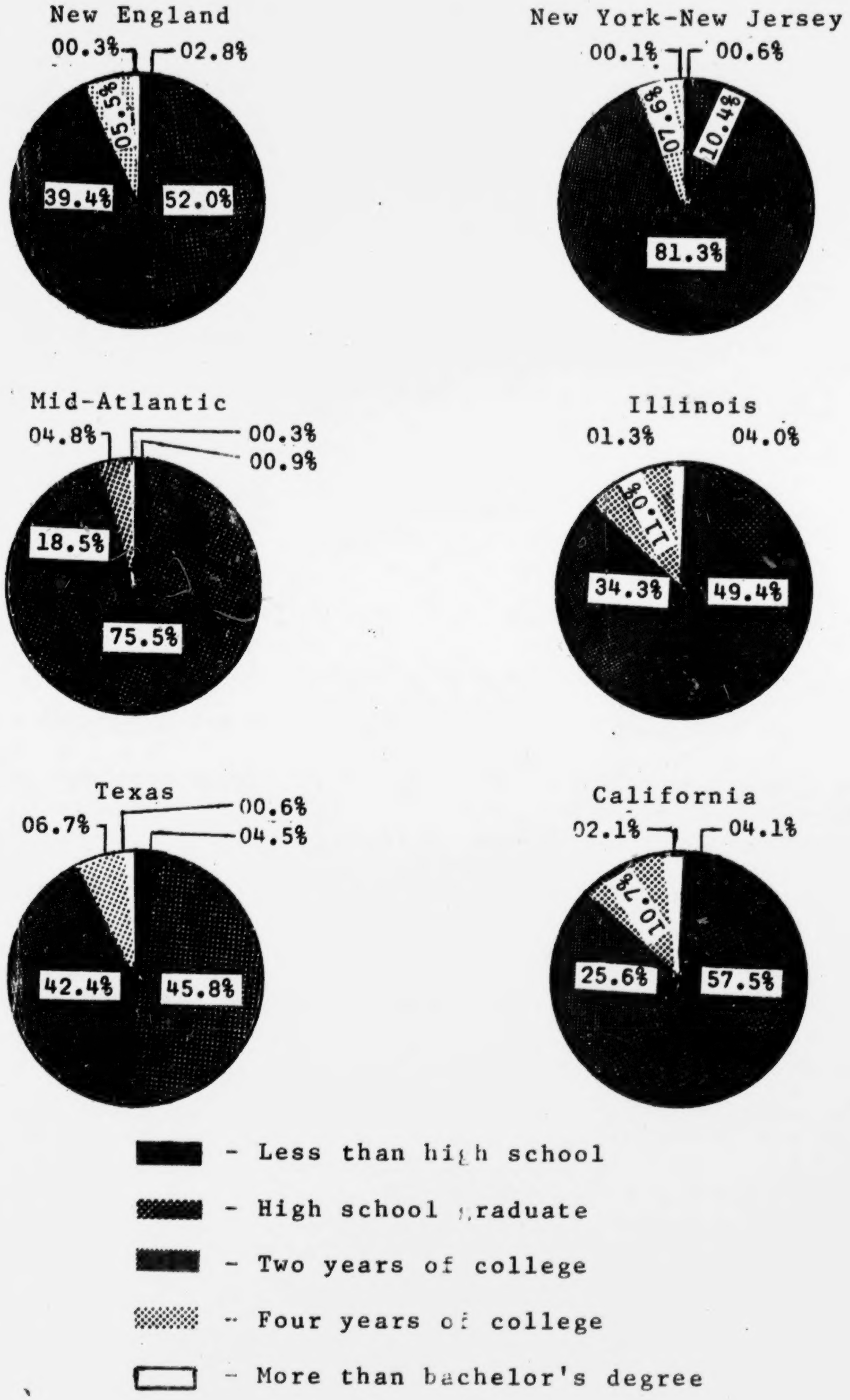
Geographical Zones

Having examined the responses to each item individually, the next step of the analysis was to investigate the relationships between these responses. The purpose of this analysis was to identify those variables which appear to have had a notable effect upon the responses. This was done by separating the data into groups according to the variable in question and calculating appropriate statistics for the groups. Space limitations would not allow a report on all of the relationships investigated, and therefore, only those which appeared most noteworthy have been treated in this section.

The first factor under consideration was geographical zones. The responses were separated into six zones: (1) New England, (2) New York-New Jersey, (3) Mid-Atlantic, (4) Illinois, (5) Texas, and (6) California. Some differences appeared with regard to the kinds of products with which the companies in these areas were concerned. For example, it was not surprising to find that a relatively large number of Mid-Atlantic and New England companies were concerned with textile mill products and clothing. But these differences were small and inconsequential to the purpose of the study.

The educational backgrounds of the technicians reported from each zone are displayed in Figure 33. With the exception of New York-New Jersey, the technicians were predominantly high school graduates with less than two years of college training. The great bulk of New York and New Jersey technicians were people who had two years of college training. Also, a relatively large proportion of Illinois and California technicians had completed four years of college.

FIGURE 33: EDUCATIONAL BACKGROUNDS OF TECHNICIANS BY GEOGRAPHICAL ZONES



There were some differences between the zones with regard to what programs the companies felt produced the most satisfactory technicians. Figure 34 displays the percentage of companies in each geographical zone which assigned ranks 1 through 4 to each given program, according to their order of preference. In every zone except New York-New Jersey, the four-year university with technical trainee programs was most frequently ranked the highest. In New York-New Jersey, other companies received the most first rankings and was, therefore, considered the program producing the most satisfactory technicians.

The technical high school was not ranked highly in any zone, but companies in New England and Mid-Atlantic zones tended to rank it higher than those in other zones. This was, no doubt, due to the quality of technical high schools and the longer history of technical schools in these zones. Industrial concentration and geographical occupational mobility, in all likelihood, are realistic causal factors in the choice of other companies.

Figure 35 displays the percentage of technicians acquired in the last two years from each of five given sources. It can be seen that a relatively large percentage of the technicians in Texas were acquired from public technical post-high schools. A large percentage of California technicians were acquired from universities with technical trainee programs, and a relatively large percentage of Mid-Atlantic technicians were from other courses. The other sources listed were largely high school graduates who were given industrial training.

FIGURE 34: PREFERENTIAL RANK OF TECHNICIAN PROGRAMS BY GEOGRAPHICAL ZONES

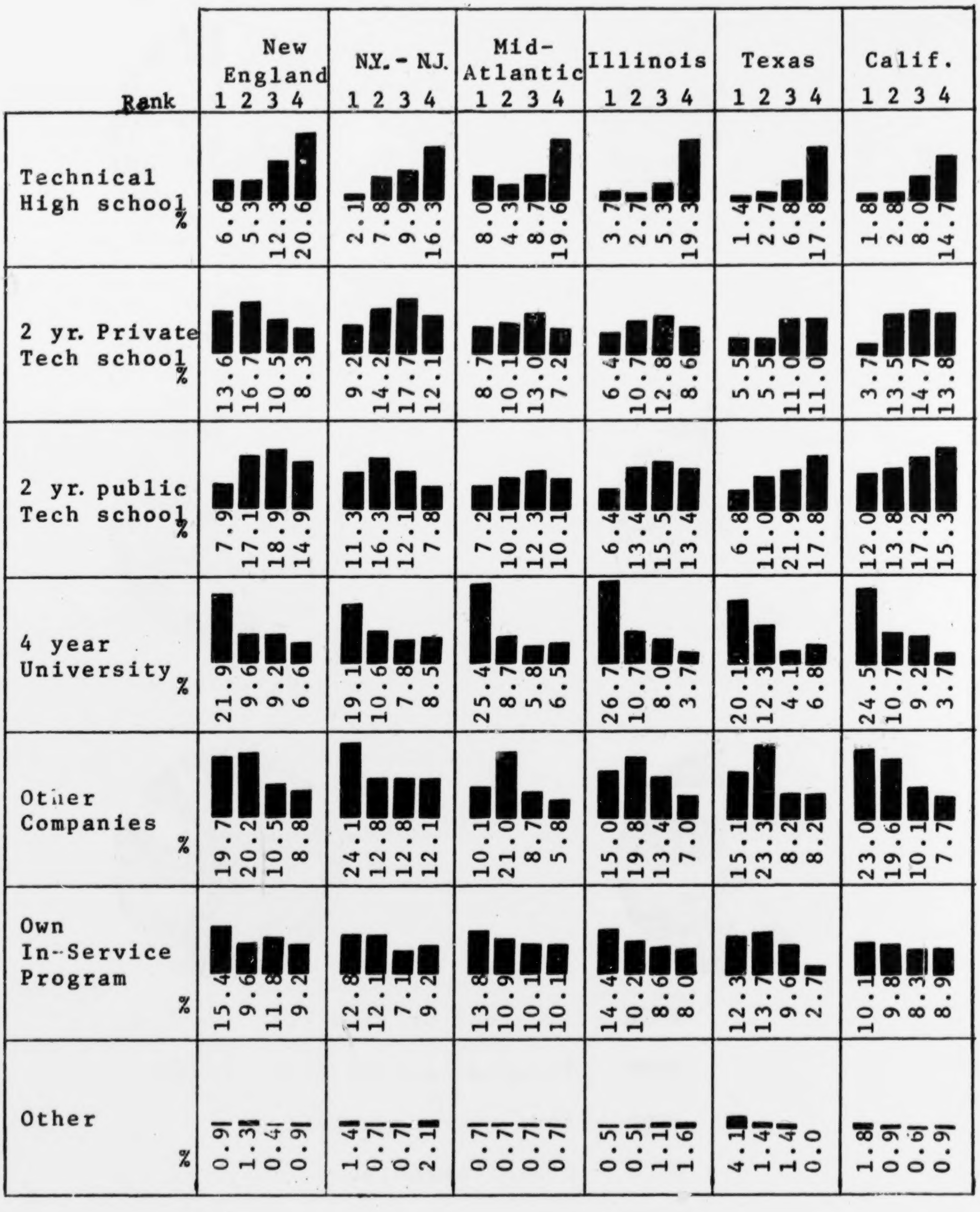
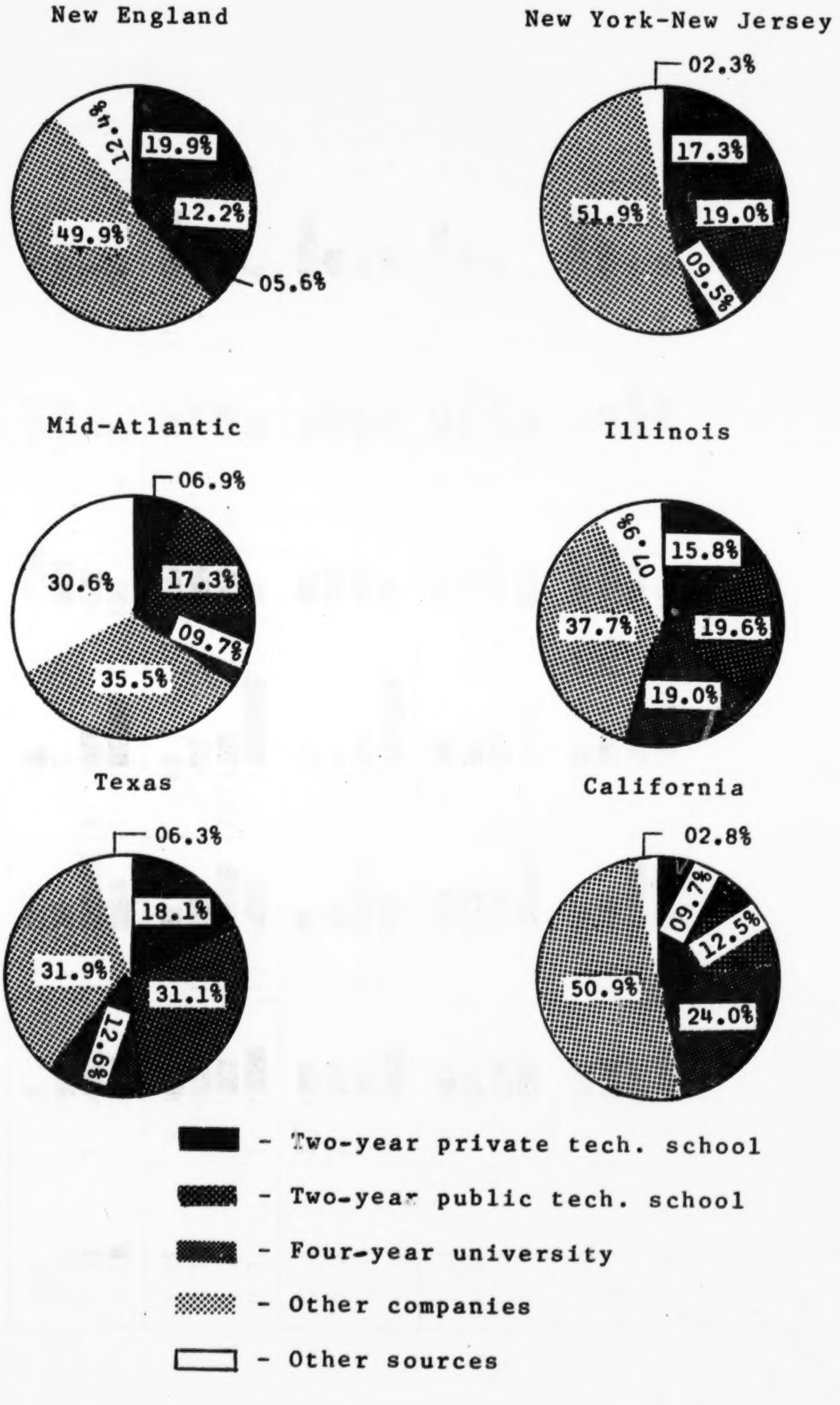


FIGURE 35: SOURCES OF TECHNICIANS ACQUIRED WITHIN TWO YEARS BY GEOGRAPHICAL ZONES



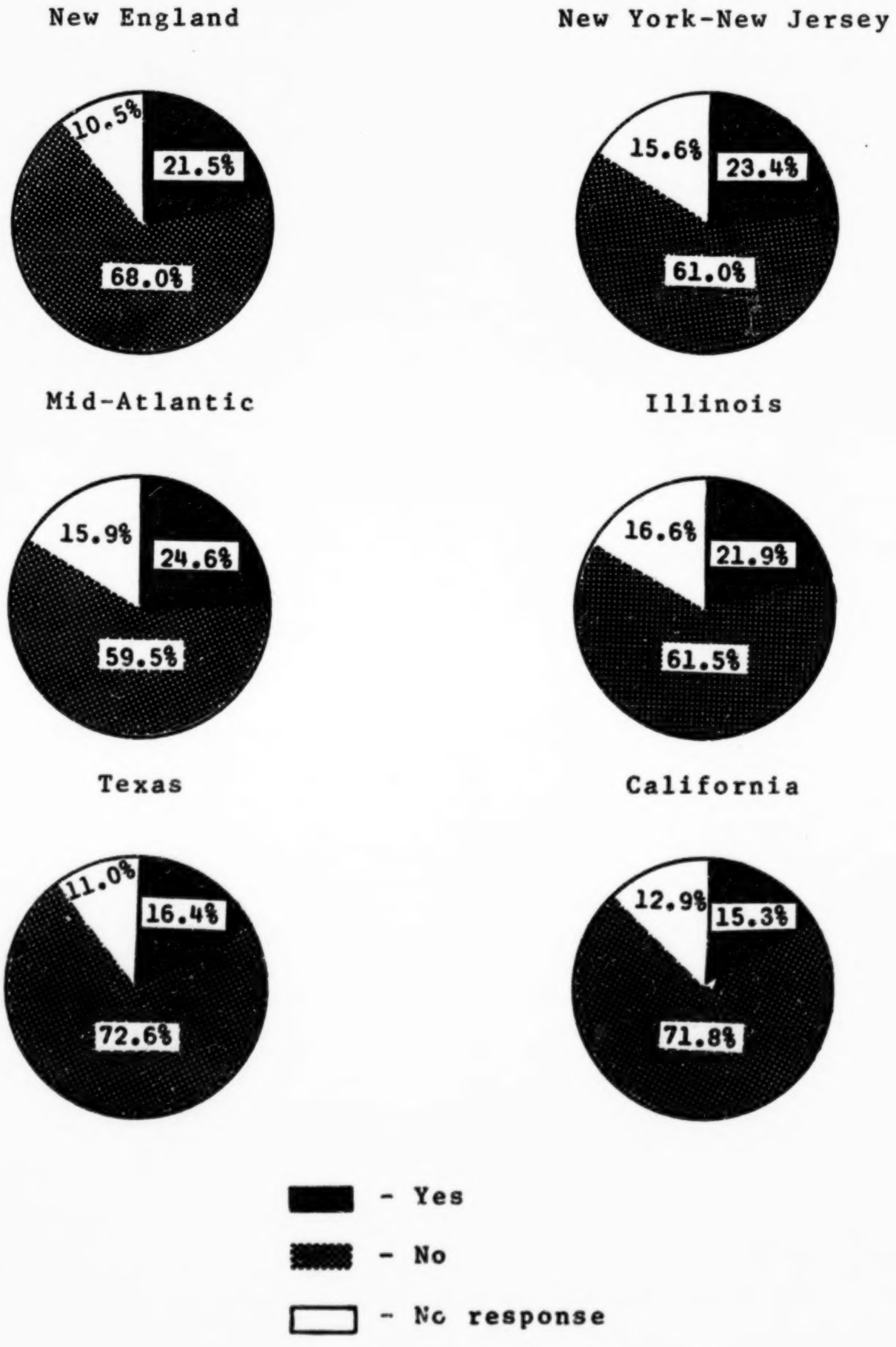
Some additional observations about the preferences and sources for technicians may be made at this point. Illinois companies acquired their technicians equally from three different sources: the two-year private technical school, the two-year public technical school, and the four-year university. In New York and New Jersey, the companies choseequal numbers from both private and public two-year technical schools. The great majority, however, came from other companies. The companies in New England obtained half of their technicians during the last two years from other companies, and their second most frequently used source was the two-year private technical school with the two-year public school and other sources sharing equally as a source. While the four-year university program was the preference for the sample as a whole, it should be noted that California led as being the most fortunate in obtaining almost one-fourth of their technicians from the university source. California was followed by Illinois, where one-fifth of the technicians came from a university source. Texas followed by obtaining over one-tenth of their technicians from a university source. Companies in New York and New Jersey, along with the Mid-Atlantic states, were able to obtain slightly less than one-tenth of their technicians from this university source, with New England obtaining only one-twentieth of their technicians from the four-year university source. All the zones receive substantial proportions of their technicians, between one-third to one-half, from other companies. For the most part, only a minority of the technicians were received from sources other than those listed. However, in New England over one-tenth of the technicians were acquired from other sources, and in the Mid-Atlantic states, nearly one-third came from other sources, primarily high schools.

Figures 36 and 37 display the percentages of responses from each zone with regard to whether or not the companies had in-plant training programs for their technicians. Such programs were more frequent in the three eastern zones (New England, New York-New Jersey, Mid-Atlantic) and Illinois than they were in Texas and California. There was a remarkable unanimity among the six zones regarding the distribution of companies, according to whether they reported having in-plant training for their technicians. The distribution for each zone is shown graphically in Figure 37. Four zones in the study, (New England, New York-New Jersey, Mid-Atlantic, and Illinois) reported that nearly one-fourth of the companies in each of these zones had some form of in-plant training for technicians. The remaining two zones of the study (Texas and California) indicated that slightly in excess of one-sixth of the companies had some form of in-plant training program for technicians. If one interprets

FIGURE 36: FREQUENCY OF COMPANY IN-PLANT TRAINING PROGRAMS FOR TECHNICIANS BY GEOGRAPHICAL ZONES

Geographical Area	Yes, We Have Program		No, We Have No Program		No Response	
New England	49	21.5	155	68.0	24	10.5
N. Y. - N. J.	33	23.4	86	61.0	22	15.6
Mid-Atlantic	34	24.6	82	59.4	22	15.9
Illinois	41	21.9	115	61.5	31	16.6
Texas	12	16.4	53	72.6	8	11.0
California	50	15.3	234	71.8	42	12.9
All Responses	219	20.0	725	66.3	149	13.6

FIGURE 37: DISTRIBUTION OF COMPANY IN-PLANT TRAINING PROGRAMS FOR TECHNICIANS BY GEOGRAPHICAL ZONES



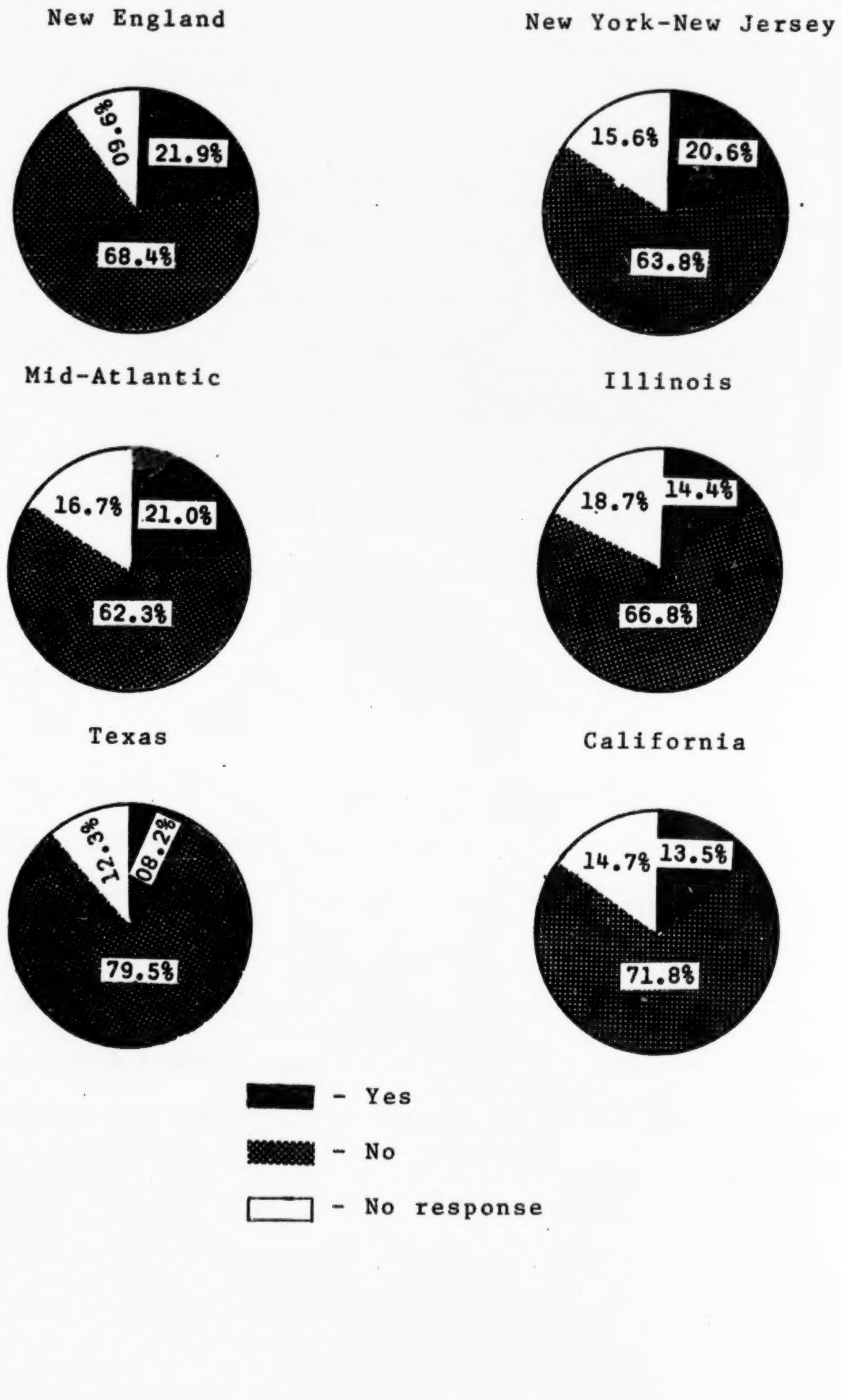
no response as a negative response, the stark reality of the status of in-plant training programs in the sample is evident. It is reasonable to conclude that the great majority (at least 3/4) of the industries in this country do not have an in-plant training program for technicians. This would suggest that while the schools, both public and private, including universities, are unable to meet the need for technicians, industry is, by and large, doing little to help itself in the way of programs when faced with the need for technicians.

Figures 38 and 39 display the percentage of respondents from each zone which reported having or not having an in-service training program for their technicians. One-fifth of the companies in the three eastern zones had such a program, whereas one-seventh of the companies in Illinois and California had in-service programs. Texas industries report only 8% having in-service

FIGURE 38: FREQUENCY OF IN-SERVICE TRAINING PROGRAMS FOR TECHNICIANS BY GEOGRAPHICAL ZONES

Geographical Area	Yes, We Have Program		No, We Have No Program		No Response	
New England	50	21.9	156	68.4	22	9.6
N. Y. - N. J.	29	20.6	90	63.8	22	15.6
Mid-Atlantic	29	21.0	86	62.3	23	16.7
Illinois	27	14.4	125	66.8	35	18.7
Texas	6	8.2	58	79.5	9	12.3
California	44	13.5	234	71.8	48	14.7
All Responses	185	16.9	749	68.5	159	14.5

FIGURE 39: DISTRIBUTION OF COMPANY IN-SERVICE TRAINING PROGRAMS FOR TECHNICIANS BY GEOGRAPHICAL ZONES



programs. Program patterns of both in-plant training and in-service programs have a reasonably similar configuration for industry. This suggests that overall training policy in industry is substantially the same, whether the training takes place within the corporate structure or avails itself of outside educational resources. Also, the possibility exists that program imitation is a highly developed practice.

The data did not allow any reliable analysis of which areas will have the greatest need for technicians in the future. One can say, however, that the median need for technicians which companies anticipate in the next five years is 3-1/2 technicians per company, and that this figure is essentially the same for each zone. There were some notable differences in the percentages of needed technicians which the respondents felt should possess a bachelor's degree. These percentages are displayed in Figure 40. Companies in Illinois and in California placed the most emphasis upon the bachelor's degree.

There were some differences in the kinds of technicians needed in the separate geographical zones. No tests of significance are appropriate for these kinds of data; therefore, the reliability of these differences must remain in question. However, the findings are suggestive. Figure 41 lists the percentage of needed technicians for each geographical zone listed in each area of technology given in the study. The area of greatest need was electrical/electronic technology in every zone except Illinois and Mid-Atlantic, where there was a greater need for mechanical technicians. The need for mechanical technicians was especially predominant in Illinois, perhaps due to the heavy concentration of the machine tool industry in the Midwest and especially in the State of Illinois.

FIGURE 40: REQUIREMENTS IN NEXT FIVE YEARS FOR TECHNICIANS WITH BACHELOR'S DEGREE BY GEOGRAPHICAL ZONES

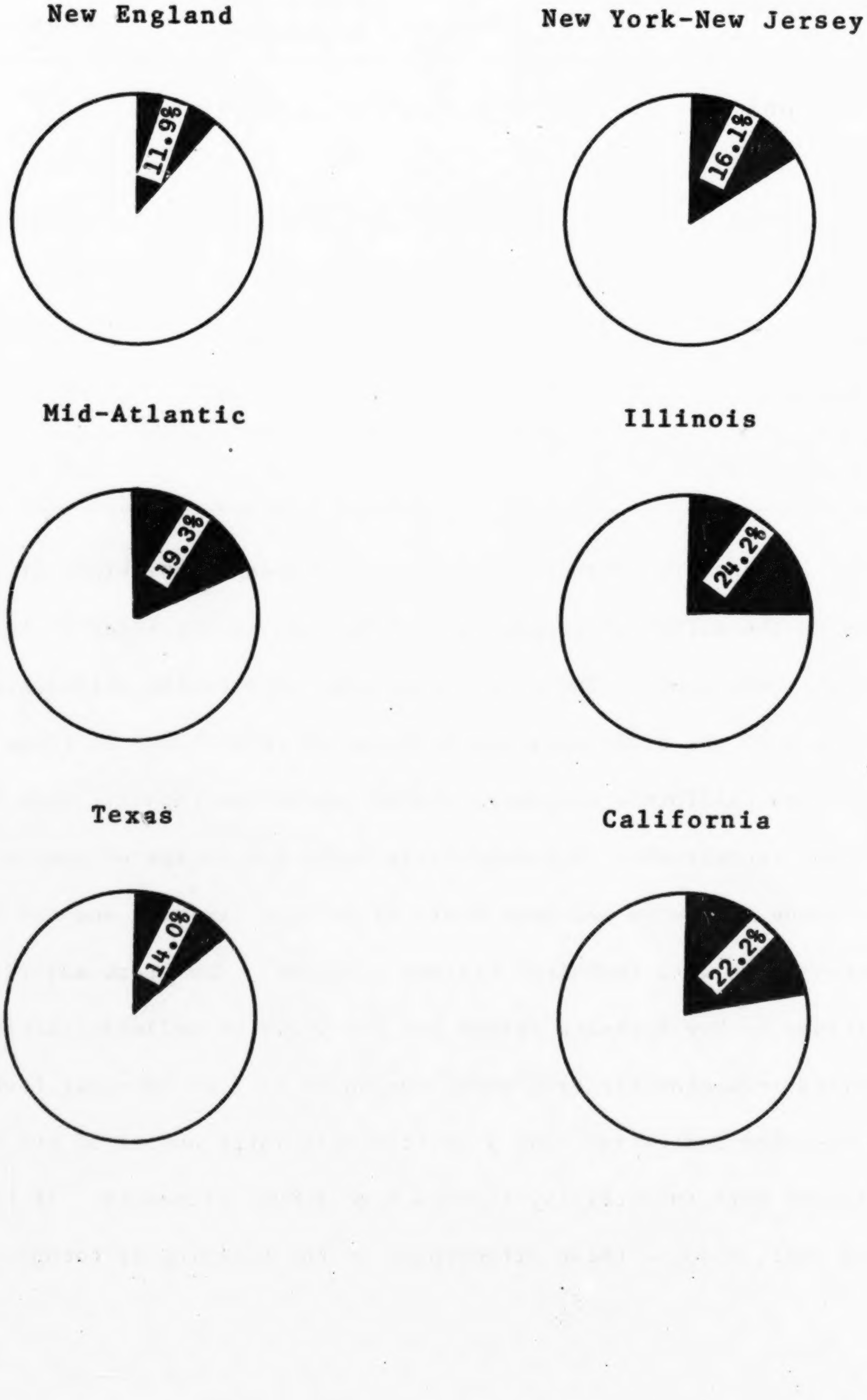


FIGURE 41: NEEDED TECHNICIANS IN TECHNOLOGICAL AREAS BY GEOGRAPHICAL ZONES

Geographical Zone	Chemical	Metals	Electrical - Electronics	Mechanical	Others
New England	11.2	6.2	47.8	31.3	3.6
N. Y. - N. J.	10.2	5.8	57.9	20.1	5.9
Mid-Atlantic	22.2	4.1	25.8	27.8	20.1
Illinois	10.0	9.3	17.9	57.7	5.0
Texas	9.6	11.8	55.7	13.7	9.2
California	9.7	8.3	42.0	28.6	11.4
All Responses	11.0	7.4	43.4	29.9	8.3

In summary, there were some differences in the kinds of industry located in the different geographical zones and in the kinds of technicians needed in these zones. There were also some interesting differences obtained with regard to the preference for training of technicians in these zones. Illinois and California companies placed particular emphasis upon the bachelor's degree for technicians. A particularly large percentage of the technicians within these two zones had four years of college training and had been trained in universities with technical trainee programs. The great majority of technicians in New York-New Jersey had two years of college training, and they were hired predominantly from other companies or from two-year technical schools. There was some indication that a particularly large number of the Mid-Atlantic technicians were industrially-trained high school graduates. It is interesting to note that, despite these differences in the training of technicians within the different zones, the responses from each zone indicate that the technicians presently being hired have a greater amount of formal education than did those hired in the past. Also, the technicians needed in the future should have an even greater amount of formal training.

Industrial Classification

The groups of companies which checked each given industrial classification in item 1 were analyzed separately, and a highly complex pattern of responses was obtained. The location of the companies, the size of the companies, the number of technical personnel employed, the appropriate training for technicians, and the future need for technicians were all related to the kinds of products with which the companies were concerned. Elaboration of these relationships was not within the scope of this report, but it should be noted that industrial classification is an important determinant of technical needs.

Company Size

In order to examine the relationship between company size (number of employees) and the responses obtained, the sample companies were divided into six groups according to the number of employees which they reported. Figure 42 displays these employment categories and the number of companies in each.

There was a strong correspondence between the number of employees reported and the other employment figures requested. Figure 32 displays the high correlation coefficients obtained with production employees (97.25), number of engineers (87.19), number of technicians (72.10), and number of technicians needed in the next five years (64.38). A similar degree of correspondence was found between the number of employees and gross dollar value of the company's

FIGURE 42: DISTRIBUTION OF SAMPLE COMPANIES BY NUMBER OF EMPLOYEES

Number of Employees	Number of Companies	Percentage of Companies
1 to 49	93	8.5
50 to 99	252	23.1
100 to 249	377	34.5
250 to 999	251	23.0
1,000 and up	108	9.9
Unknown number	12	1.1

industrial product. An estimated product-moment correlation coefficient of 79.52 was obtained. Because a classification scale of values from 1 to 9 was used, this was a conservative estimate.

Figure 43 displays the mean number of employees, engineers, technicians, and needed technicians reported by the companies in each employment category. These same data are displayed in Figure 44 in terms of numbers of engineers, technicians, or needed technicians reported per 100 employees. These data show that the largest companies employed the largest proportion of engineers, and the smallest companies employed the largest proportion of technicians. The smallest companies, according to employment, also anticipated the greatest amount of future growth for their technician staffs. Companies with fewer than 300 employees generally anticipated a need for more additional technicians in the next five years than the numbers which they currently employ. Those with more than 300

FIGURE 43: MEAN NUMBER OF EMPLOYEES BY EMPLOYMENT CATEGORY

Number of Employees	Mean Number of Employees	Mean Number of Engineers	Mean Number of Techs.	Mean Number of Needed Techs.
1,000 and up	6,724.70	469.63	235.37	52.24
250 - 999	459.24	16.23	14.84	10.43
100 - 249	152.76	3.96	4.04	4.95
50 - 99	68.88	2.43	3.58	4.01
1 - 49	31.40	1.25	2.03	2.88
Unknown number	-	1.42	2.42	1.17
Total	841.17	52.18	29.08	10.45

FIGURE 44: NUMBER OF TECHNICIANS PER 100 EMPLOYEES NEEDED IN NEXT FIVE YEARS

Number of Employees	Engineers	Technicians	Needed Technicians
1,000 and up	6.98	3.50	0.78
250 - 999	3.53	3.23	2.27
100 - 249	2.59	2.64	3.24
50 - 99	3.53	5.20	5.82
1 - 49	3.97	6.47	9.18

employees anticipated a need for fewer additional technicians than the numbers which they currently employ.

Figure 45 shows the percentage of engineers reported as serving what has been defined as a technician's function. This figure shows that the smaller the company, the greater the percentage of the company's engineers reported as serving a technician's function. Similarly, Figure 46 displays the percentage of technicians which were reported as serving what has been defined as an engineering function. Once again, the smaller companies tended to report a larger percentage of their technicians as serving an engineering function. The most apparent conclusion to be drawn from the relationships is that the larger the company, the greater the likelihood that the company's technological personnel were serving functions consistent with their titles. Another interpretation of these data which will be discussed later is that the larger the company, the less familiar the respondent would be with the actual duties of the company's technicians and engineers, and the greater the possibility that the respondent assumed that the engineers and technicians were serving functions consistent with their titles.

There was an inverse relationship between company size and the ratio of technicians to engineers employed. Companies with up to 100 employees generally had more technicians than engineers. Those with more than 500 employees generally had more engineers than technicians, and those with 100 to 500 employees generally had about the same number of technicians and engineers. Figure 47 displays this relationship.

FIGURE 45: DISTRIBUTION OF ENGINEERS SERVING TECHNICIAN'S FUNCTIONS BY EMPLOYMENT CATEGORY

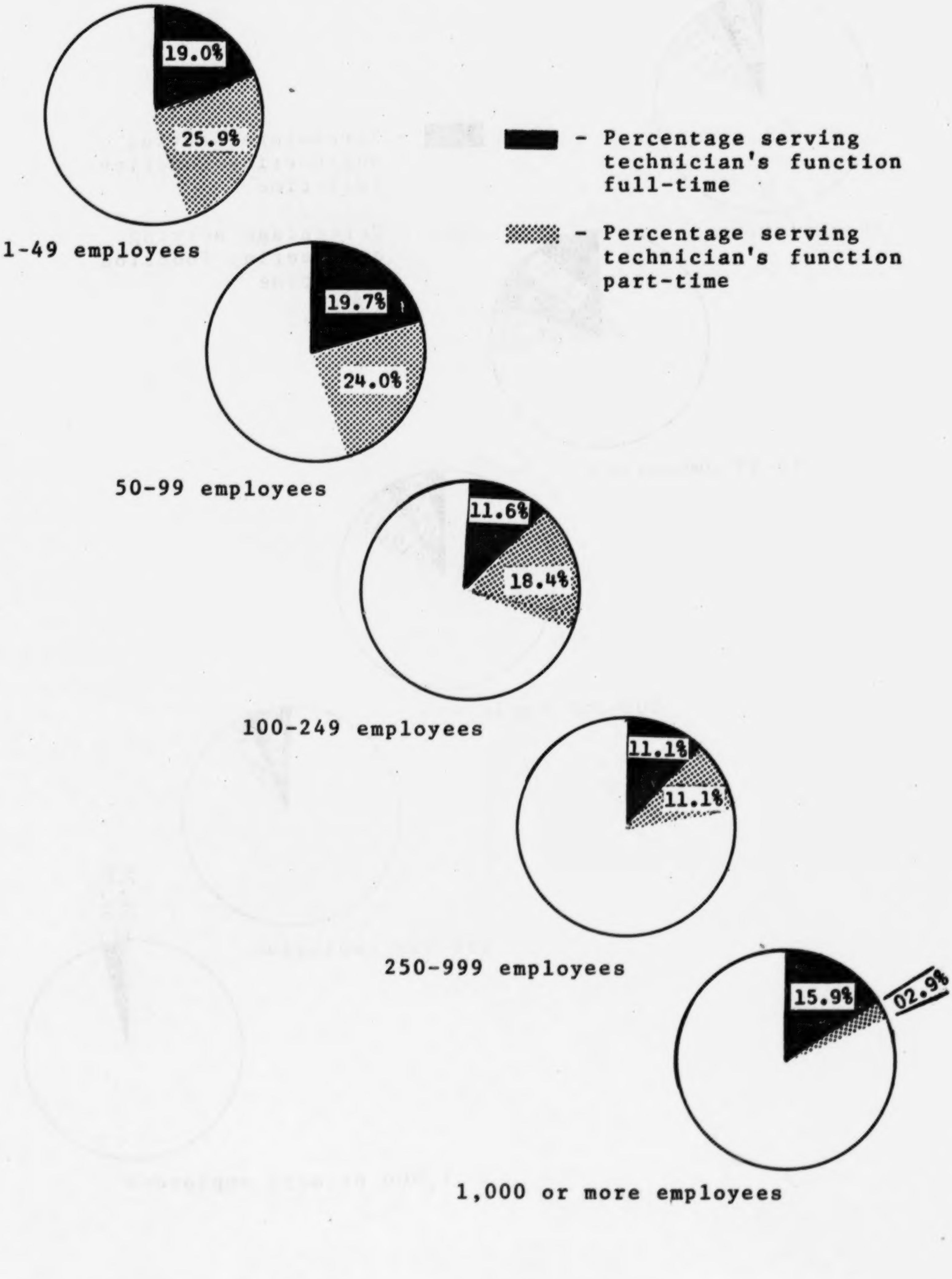
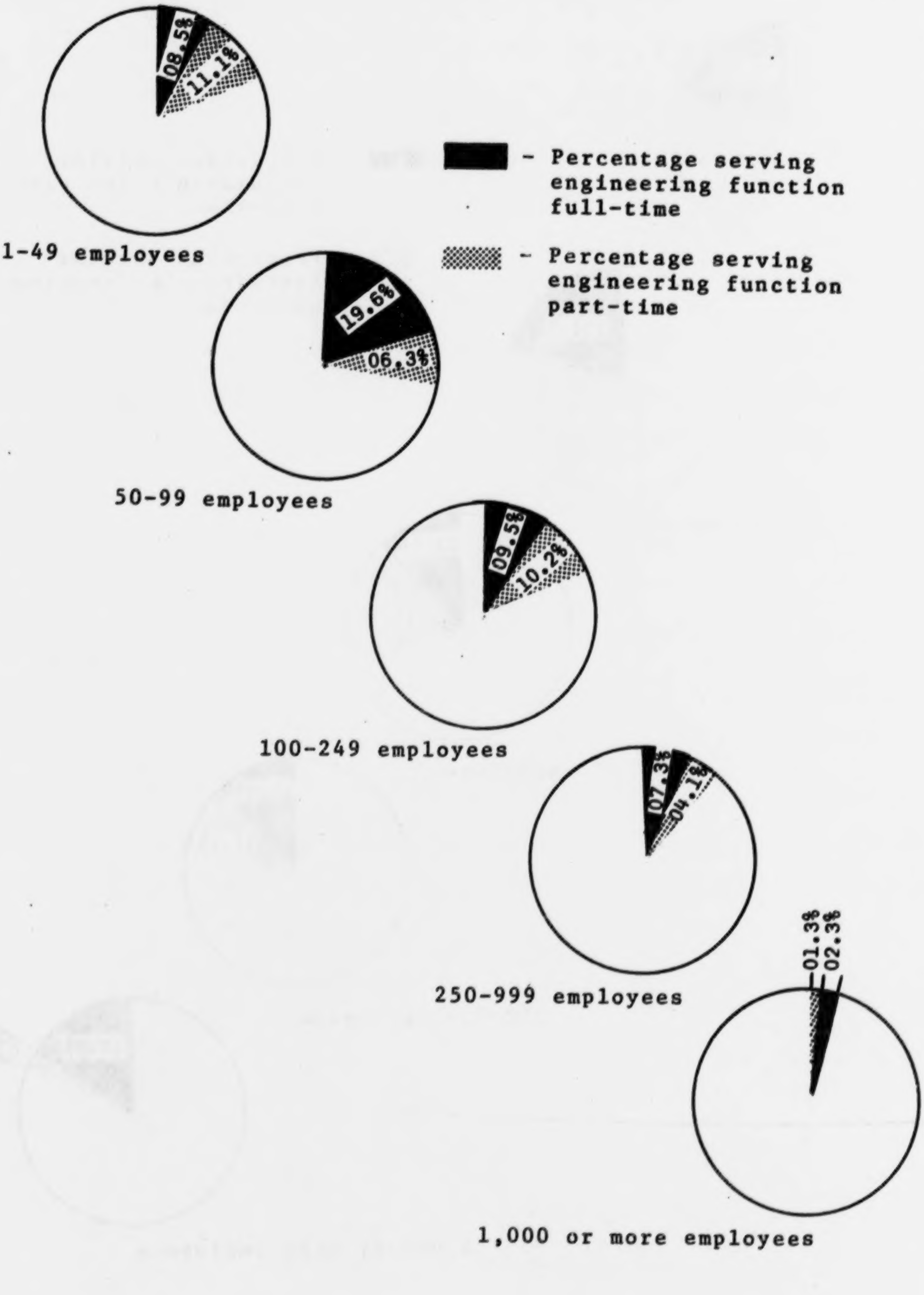


FIGURE 46: DISTRIBUTION OF TECHNICIANS SERVING ENGINEER'S FUNCTIONS BY EMPLOYMENT CATEGORY



1-49 employees

50-99 employees

100-249 employees

250-999 employees

1,000 or more employees

FIGURE 47: TECHNICIAN-ENGINEER RATIOS

Number of Employees	Technicians per Engineer
1,000 or more	0.50 to 1
250 - 999	0.91 to 1
100 - 249	1.02 to 1
50 - 99	1.47 to 1
1 - 49	1.63 to 1
Unknown number	1.71 to 1

Figure 48 displays the percentages of companies' technicians which were reported to have attained each given level of educational achievement. The percentage of technicians with two years of college training increased with increasing company size, and the percentages with four years of college training tended to decrease slightly with increasing company size. Generally, there was little difference in the educational backgrounds of technicians in large and small companies.

Figure 49 displays the percentage of companies within each employment category which assigned ranks from 1 to 4 to the given technician programs. The ranks represented preferences for the programs which the companies felt provided the most satisfactory technicians. The larger companies ranked two-year technical schools and four-year universities especially high, thus expressing a particular awareness of these programs as producing satisfactory technicians.

FIGURE 48: EDUCATIONAL BACKGROUNDS OF TECHNICIANS AS RELATED TO EMPLOYMENT CATEGORY

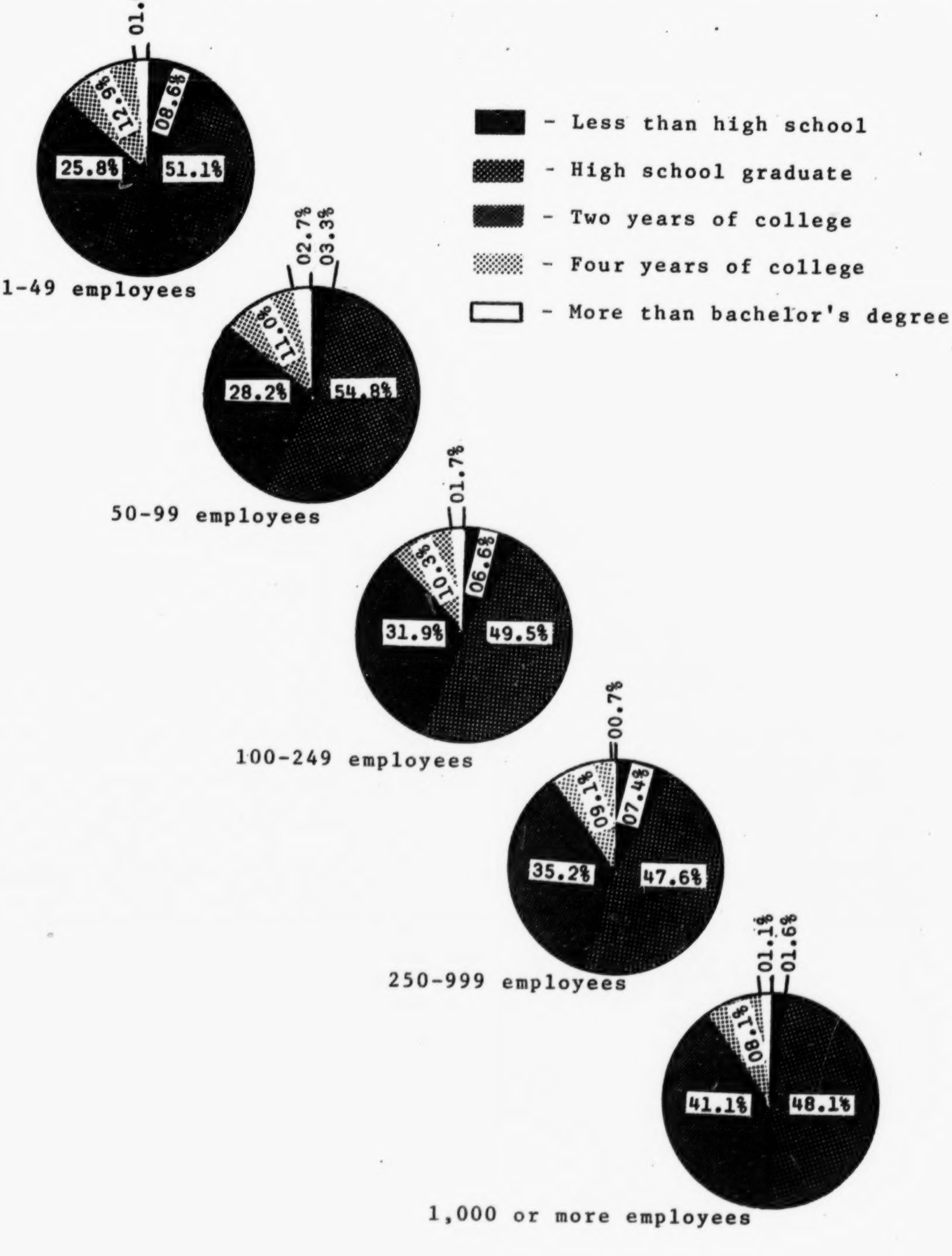
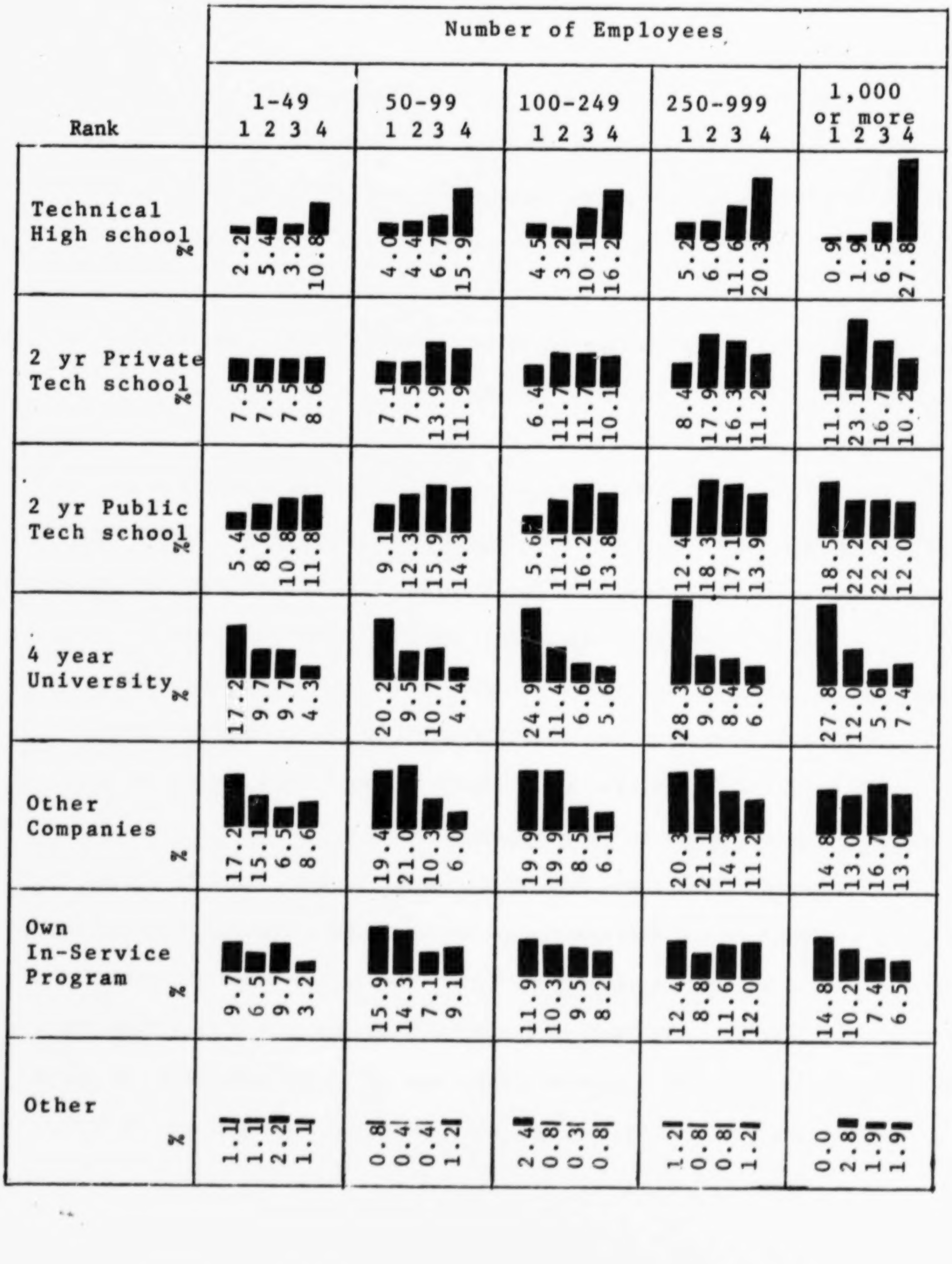


FIGURE 49: PREFERENTIAL RANK DISTRIBUTION OF TECHNICIAN PROGRAMS



No clear relationship appeared between company size and preferences for general or specific technical training. However, the larger companies were more likely to indicate a definite preference. Figure 50 displays the preferences indicated.

The percentages of technicians hired in the past two years which were acquired from each given source are displayed in Figure 51. The larger the companies, the greater the percentages of their technicians which were hired from the two-year technical schools, and the smaller the percentages which were hired from other companies. Companies with 1,000 or more employees hired a relatively large percentage of their technicians from four-year universities with technical trainee programs. These differences are in agreement with the ranked preferences already discussed.

Except for the fact that the very small companies seldom had an in-plant training program, no relationship was obtained between company size and the percentage of companies which had in-plant training programs for their technicians. However, the larger companies did have in-service training programs for their technicians more often than companies of smaller size.

The sample companies reported that 18.4% of the technicians needed in the next five years should have a bachelor's degree. This percentage was about the same for companies in each employment category.

In summation, there was general agreement between the differences in training preferences and differences in the employment figures reported by the companies when analyzed according to size. The larger companies tended to rank the two-year post-high school technical programs more highly than the smaller companies. They had a greater percentage of technicians with two years of college training on their staffs, and they had hired a greater percentage

FIGURE 50: TRAINING PREFERENCES FOR TECHNICIANS BY EMPLOYMENT CATEGORIES

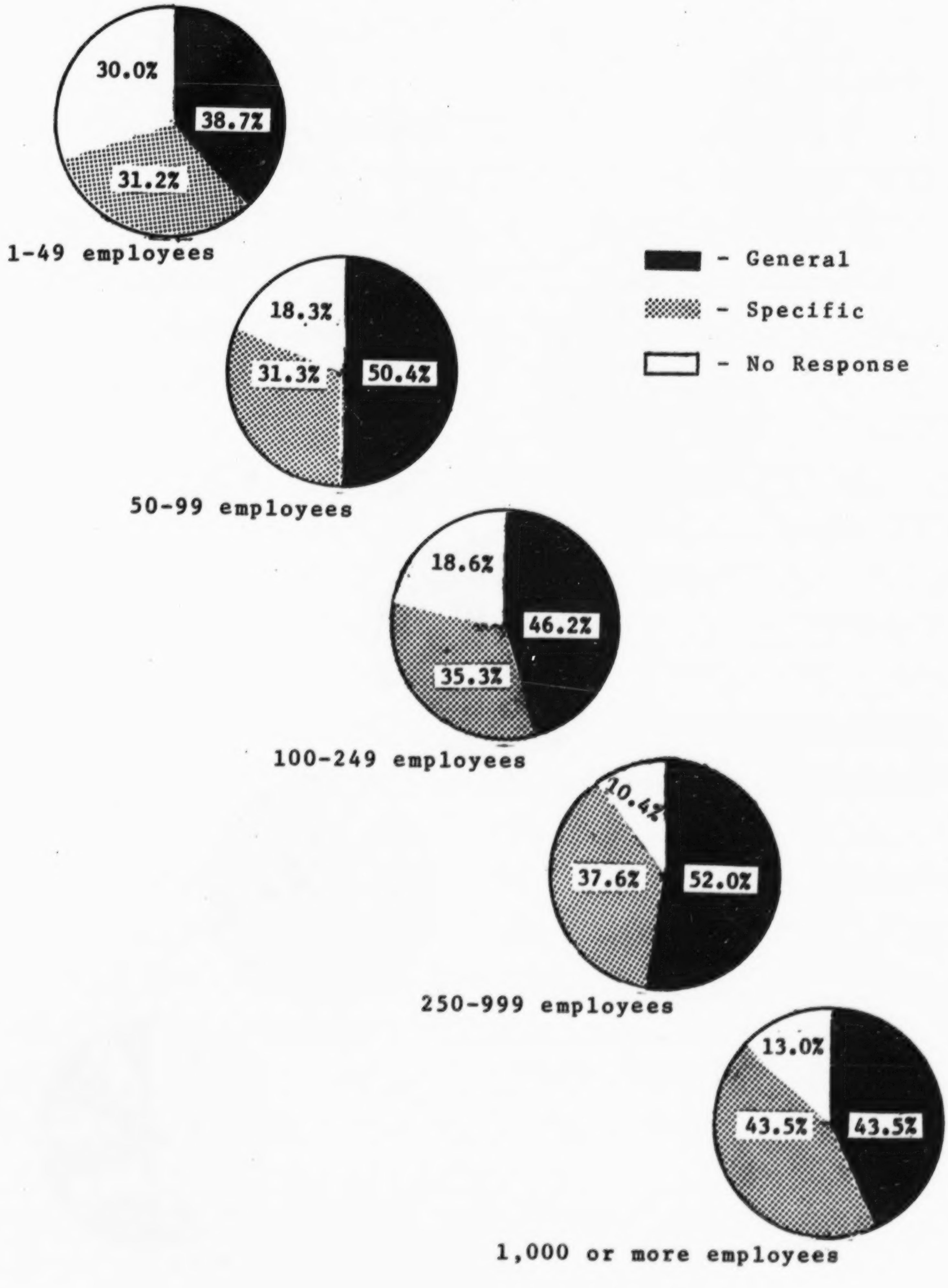
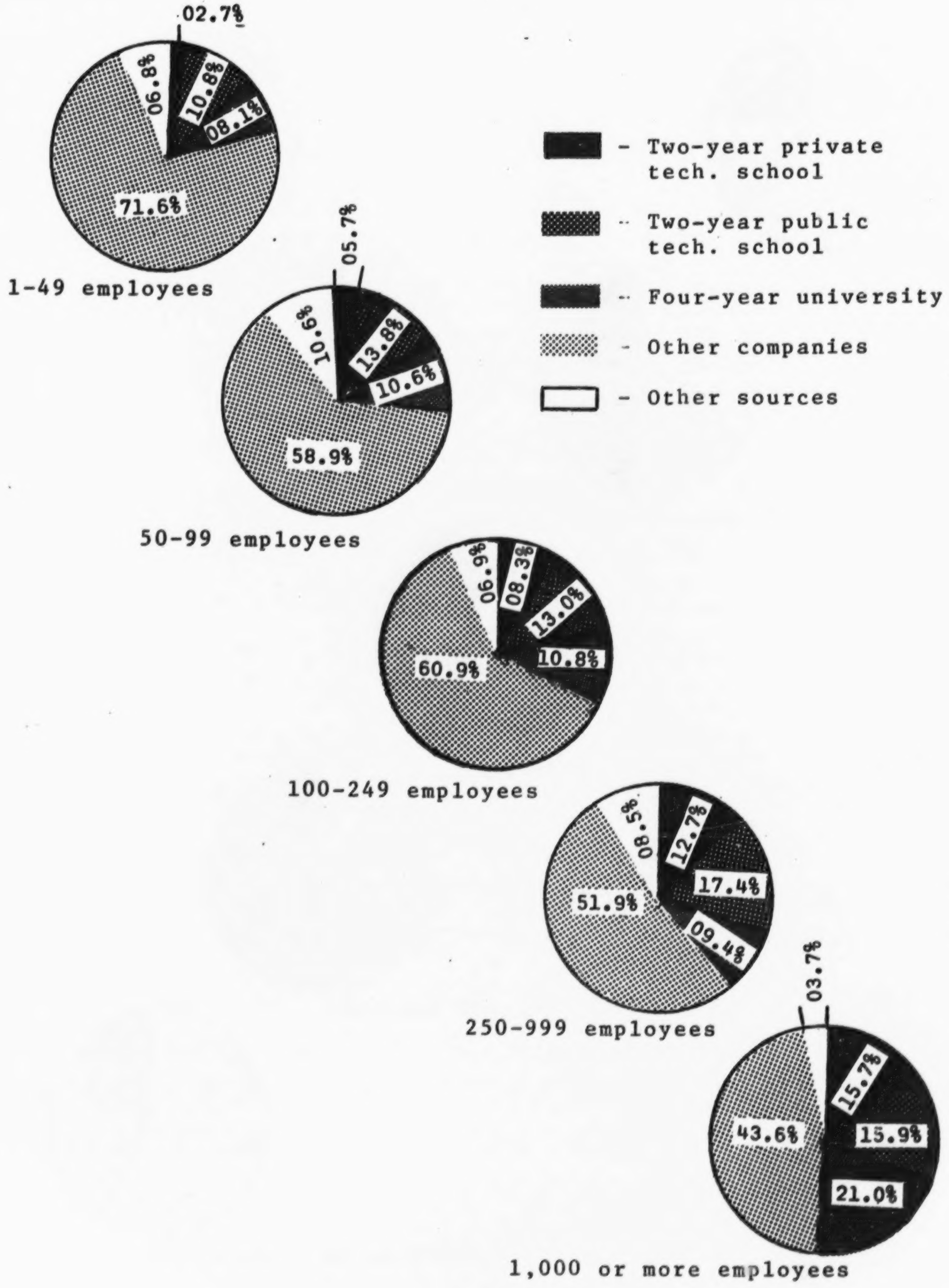


FIGURE 51: SOURCES OF TECHNICIANS BY EMPLOYMENT CATEGORIES



of technicians in the last two years from these two-year technical schools. The larger companies also tended to rank four-year universities with technical trainee programs higher than the smaller companies. Although the smaller companies had a larger percentage of technicians on their staffs with four years of college training, the larger companies had acquired a larger percentage of technicians from four-year universities in the past two years. No difference between large and small companies appeared with regard to the percentages of the future technicians which they felt should possess a bachelor's degree.

The smaller companies did not tend to rank other companies higher as sources producing satisfactory technicians than the larger companies did, but they did obtain a larger percentage of their technicians from other companies. This finding was consistent with some of the comments received which stated that the large companies train technicians and then have many of them "stolen" by the small companies. Larger companies did not report having in-plant training programs for their technicians more often than the smaller, but they did report as having more in-service training programs than smaller companies.

The larger the company, the smaller were the discrepancies reported between the titles and duties of their technological personnel. That is, the larger companies reported that a smaller percentage of their engineers were serving technician's functions, and a smaller percentage of technicians were serving engineering functions. This finding may reflect a greater degree of specialization on the part of the larger companies, allowing them to restrict the duties of their personnel to functions more consistent with their training. If this were true, one might expect the larger companies to prefer specific technical training for their technicians, but such a preference did not appear in their responses.

A few of the subjective comments suggested that the larger companies tended to give engineering titles to personnel doing a technician's work. This was not consistent with the reports made by the larger companies, indicating that a very small percentage of their engineers served technician's functions, but it may explain in part why the larger companies reported a relatively large number of engineers, while the smaller companies reported a relatively large number of technicians. It may be that the respondents from larger companies were less familiar with the duties of their many engineers and thus tended to assume that they served engineering functions.

Number of Technicians Employed

A positive product-moment correlation coefficient of 72.10 was found between the number of employees and the number of technicians reported by the companies. Thus, the number of technicians corresponded closely with the total number of employees within the companies in the sense that the larger the company's total employment, the greater were the numbers of technicians employed. An analysis of the data was made with companies separated into groups according to the number of technicians which they reported. The results were essentially the same as those reported when the companies were separated according to number of employees. It would, therefore, be repetitious to enumerate them here.

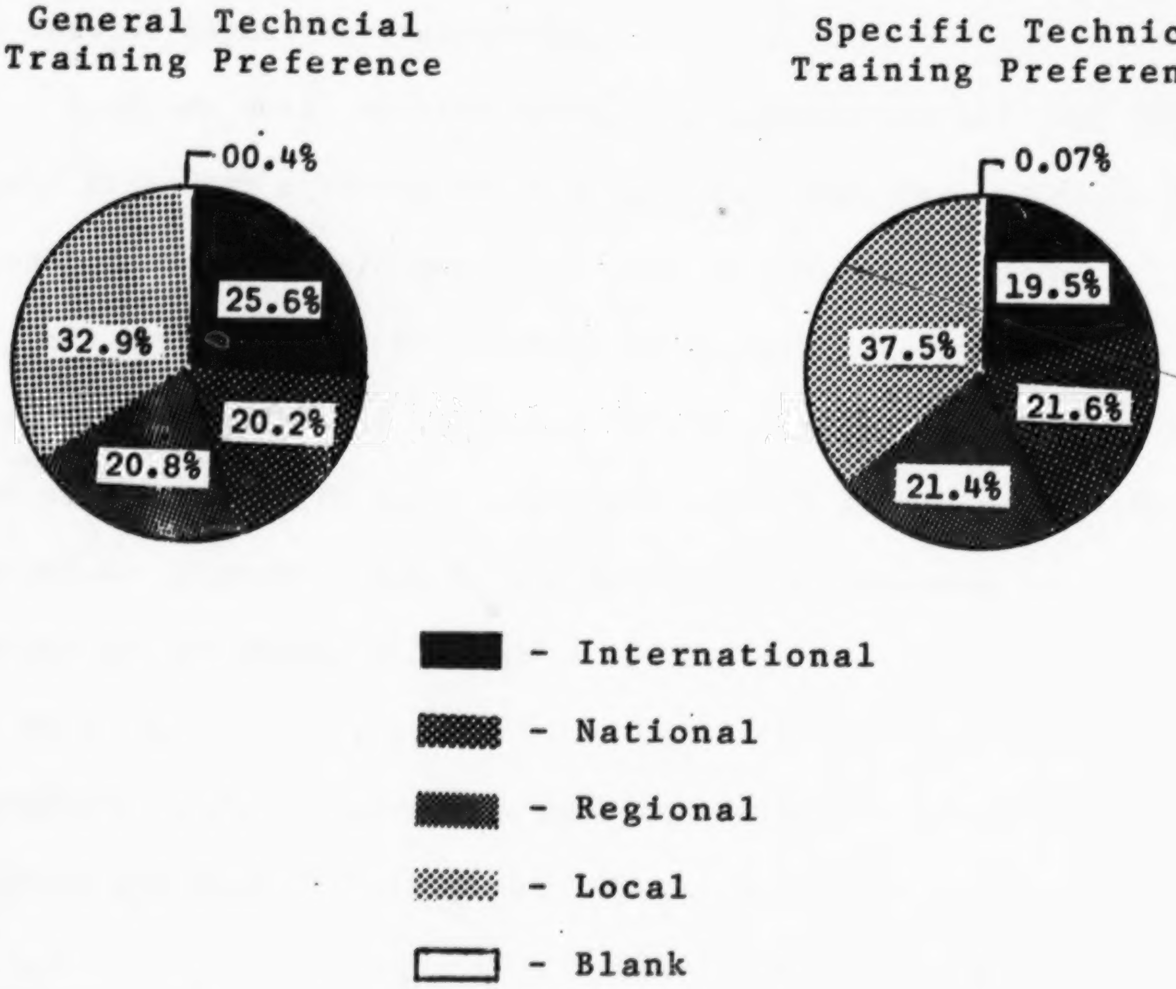
Technical Training Preference

A comparison was made between the responses of companies which indicated a preference for general technical training and those which indicated a preference for specific technical training. There were some small variations with regard to the industrial classifications of the companies. For example, about one-third of the companies concerned with food and kindred products preferred specific technical training as compared to about one-half of the companies concerned with professional and scientific instruments. The percentages for companies in other classifications ranged between these two values. Thus for all industrial classifications, from one-half to one-third of the companies expressed a preference for specific technical training.

In the comparison of data from companies preferring general as opposed to specific technical training, no differences were found in the gross dollar values of the companies' industrial products. Likewise, no differences were found in the employment figures reported. Some differences were found with regard to the geographical organizations of the companies. A larger percentage of the companies preferring general technical training had an international basic organization. On the other hand, a larger percentage of the companies preferring specific technical training were local in basic organization. Figure 52 displays the break-down of companies with each preference according to their geographical organizations.

Those companies which preferred general technical training most frequently ranked four-year universities with technical trainee programs as the most satisfactory technician program. Those which preferred specific technical training, most frequently ranked experienced technicians from other companies the highest. No other notable differences appeared in the ranking of technician programs by companies preferring general or specific technical training. These ranked preferences are displayed in Figure 53. It would appear that the companies which preferred general technical training were emphasizing formal training and education, while those which preferred specific technical training were emphasizing industrial skills and experience.

FIGURE 52: TRAINING PREFERENCES FOR TECHNICIANS BY GEOGRAPHICAL ZONES



Companies which preferred general and specific training differed with regard to the percentage of technicians acquired in the last two years from each of the given sources. This information is displayed in Figure 54. Companies which preferred general technical training obtained a much larger percentage of their technicians from four-year universities with technical trainee programs. Those which preferred specific training obtained more from other companies and two-year technical schools. Regardless of the preference (general or specific), other companies in the industry was itself the major source of technician trainees.

FIGURE 53: RANK OF PREFERRED TRAINING PROGRAMS BY TRAINING CATEGORIES

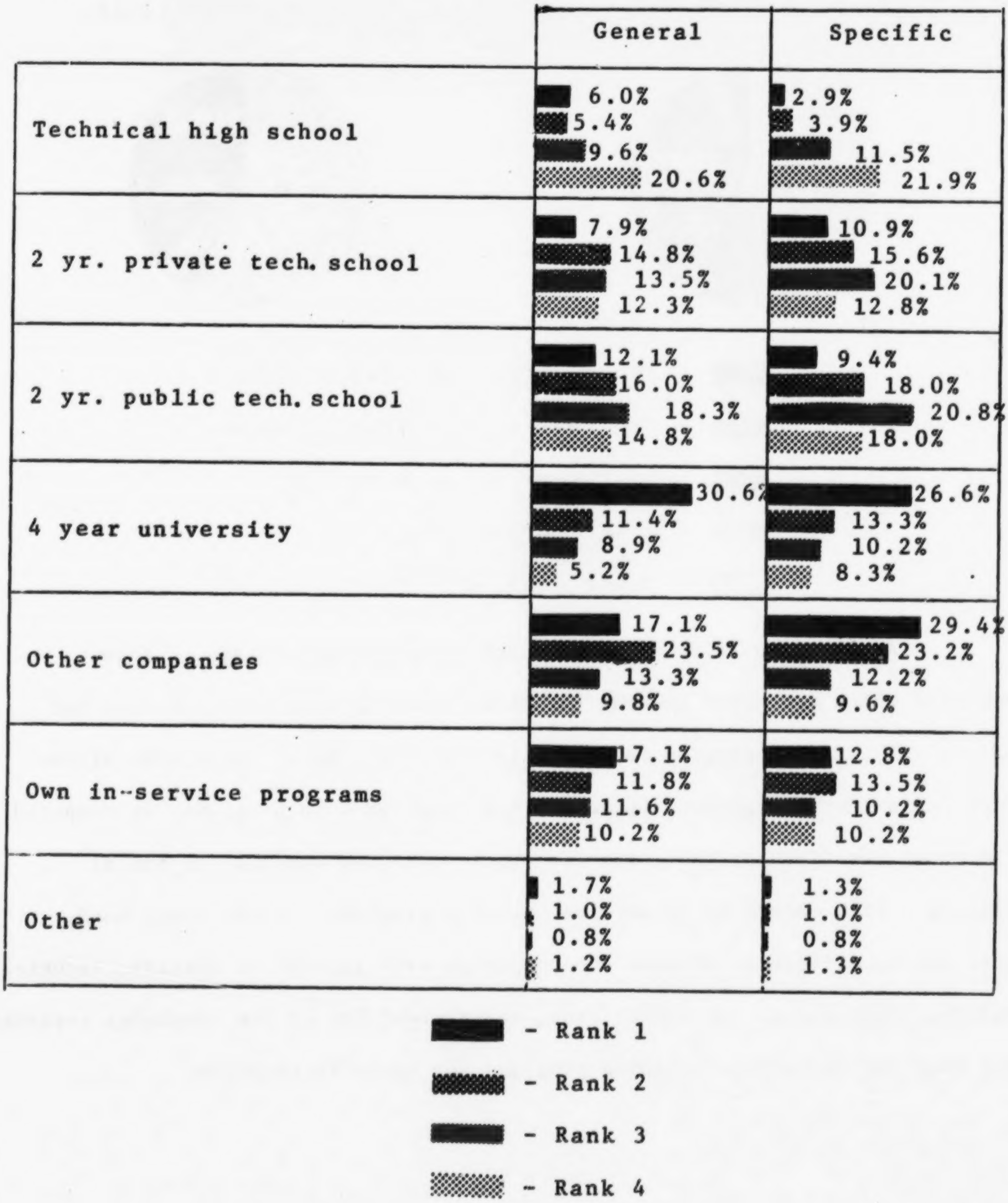
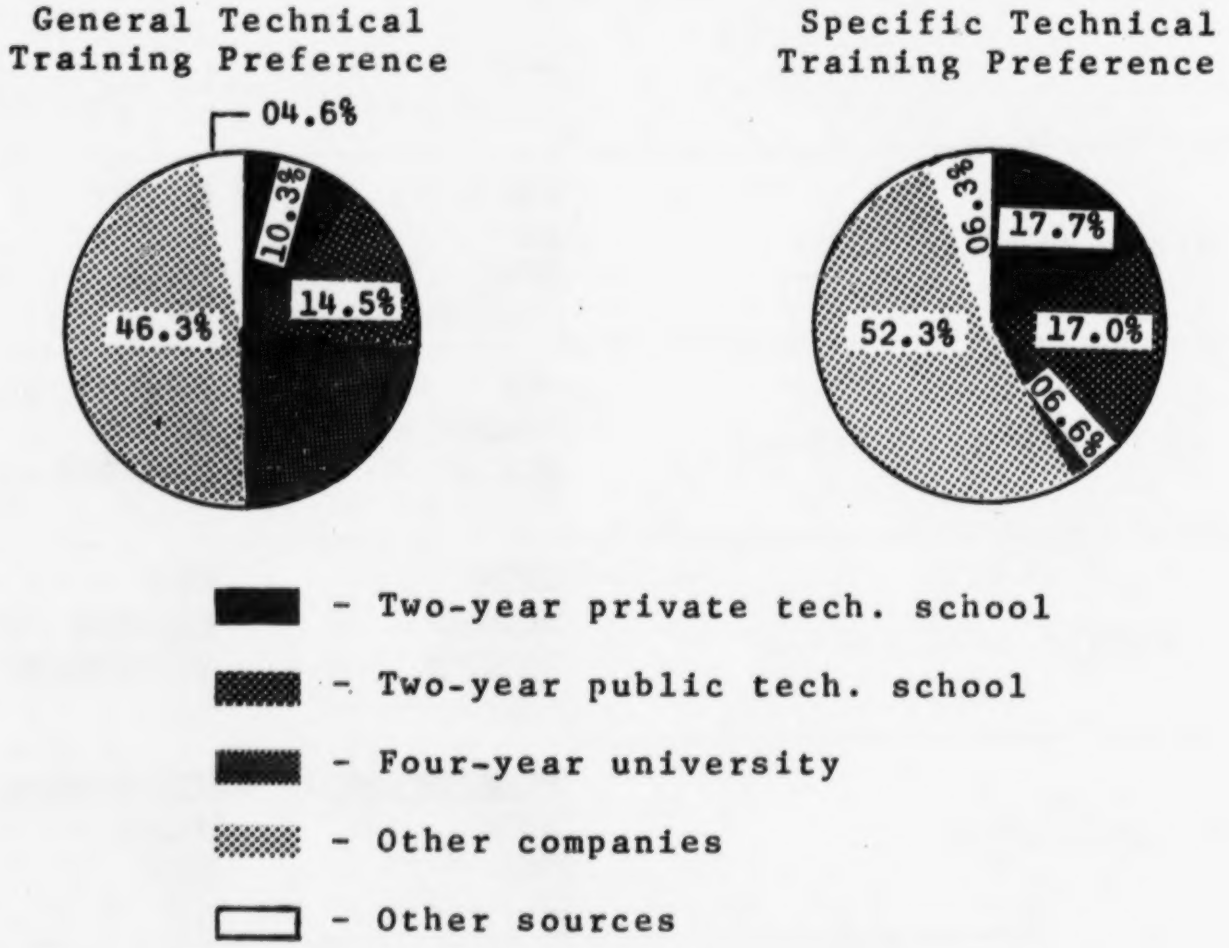
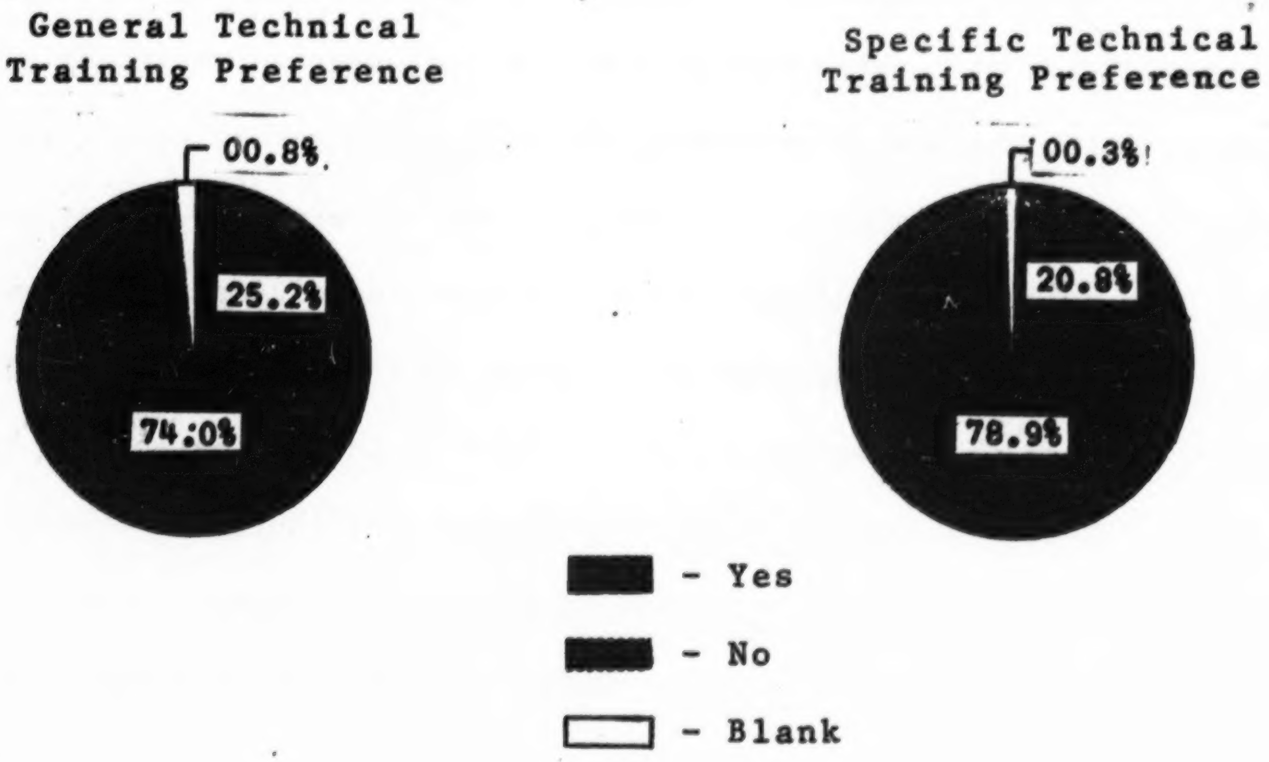


FIGURE 54: PERCENTAGE OF TECHNICIANS ACQUIRED IN PAST TWO YEARS FROM GIVEN SOURCES BY COMPANIES HAVING TECHNICAL TRAINING PREFERENCE



As shown in Figure 55, the slightly larger percentage of those companies which preferred general technical training reported that they had an in-plant training program for their technicians. About one-fourth of the companies preferring general technical training had such programs, as compared with about one-fifth of the companies which preferred specific technical training. With regard to in-service training programs, on the other hand, there was no difference between the companies with general or specific technical training preferences. In either case, about one-fifth of the companies reported that they had in-service training programs for their technicians.

FIGURE 55: DISTRIBUTION OF IN-PLANT TRAINING PROGRAMS RELATED TO TRAINING PREFERENCES



The companies which preferred general technical training wanted 20.2% of their future technicians to possess a bachelor's degree, but those which preferred specific training wanted 13.9% to possess a bachelor's degree. There was no difference in the total number of technicians which the companies anticipated they would need in the next five years. The mean numbers needed are displayed in Figure 56.

FIGURE 56: MEAN NUMBER OF TECHNICIANS PER COMPANY NEEDED IN NEXT FIVE YEARS WITH IDENTIFIED TRAINING PREFERENCE

Preference	Less than a Bachelor's Degree	At least a Bachelor's Degree	Total
General	9.59	2.43	12.02
Specific	10.62	1.71	12.33
None Indicated	1.45	0.83	2.28

In summary, a consistent pattern of differences was obtained between the responses of companies which preferred general technical training and those that preferred specific technical training. Those desiring general technical training most frequently preferred as a source four-year universities with technical trainee programs as providing the most satisfactory technicians. They obtained a much larger number of technicians from universities. They also indicated that a larger percentage of their future technicians would possess a bachelor's degree. These companies also ranked their own in-service programs relatively high and more frequently had in-plant training programs for their technicians. Their comments in item 16 indicated that they often recruited people with broad technical backgrounds and provided the specific training needed in their own in-plant programs. Thus, these companies placed particular emphasis upon formal technical education.

Companies which preferred specific technical training most frequently preferred as a source, other companies, as providing the most satisfactory technicians. Relatively large percentages of their technicians were obtained from other companies and from two-year technical schools. In their comments, these companies frequently emphasized industrial experience with specific kinds of equipment or products.

CHAPTER III

TECHNICAL TRAINING ANALYSIS

Preparation of Data

Item 19 was designed to identify specific curricular needs in technical training; a large two-way table was provided with 53 given technical occupational titles on one margin and 87 technical courses on the other. The occupations were listed in five general areas of technology: chemical technology, metal technology, electrical technology, mechanical technology, and miscellaneous.

The courses were listed in seven general areas of study: mathematics, chemistry, physics, metallurgical technology, electricity and electronics, mechanical technology, and general technology. The respondents were asked to check those courses opposite the occupations which they felt were essential or advisable preparation for the technicians employed in their company. Different symbols were used to designate essential or advisable courses. In addition, the respondents were asked to write in additions if the listing did not include occupations represented by technicians employed in their company, or courses felt to be desirable. They were encouraged to seek competent assistance when they did not feel qualified to make the necessary judgments themselves.

The results provided by the respondents for each technical occupation are summarily displayed by the bar-graph charts included in this chapter.

The title of the technical occupation is given at the top of the graph along with the number of companies which responded in regard to that occupation. A chart of courses for each of the listed occupations is included, with the exception of those occupations to which fewer than 10 companies responded.

The length of the solid bars indicates the percentage of the responding companies which felt that a given course was essential, and the length of the striped bars indicates the percentage which felt that the course was advisable. It should be noted that the length of the striped (advisable) bars begins at the end of the solid (essential) bars. Thus, if 70% of the responding companies indicated that algebra was essential and an additional 10% indicated that it was advisable, algebra would be followed on the graph by a solid bar running to the 70% gradient and a striped bar continuing from the 70% gradient to the 80% gradient. Interpreting these graphs, the total length of the bars represents the percentage of responding companies which felt that the course should be taken, and the length of the solid bars alone represents the percentage of responding companies which felt that the course must be taken. Bars representing the responses of less than 1.0% of the responding companies are not shown on the chart. In addition to the charts for each individual technical occupation, there is included a chart for each of the five general areas of technology: chemical, metal, electrical, mechanical, and miscellaneous. These charts contain summations of the data obtained for all of the occupations in that particular area of technology. Thus, for each area of technology as well as each occupation, there is provided a curricular profile of courses considered to be essential or advisable.

Standards for Interpretation

In order to interpret the charts, that is, the curricular profiles, it was deemed necessary to identify certain criteria and standards of interpretation. A jury of 13 individuals representing both industry and education were arbitrarily chosen. It was assumed that the judgments provided by this jury would constitute a valid means of appraising the data. The jury was provided with a sampling of course distributions in chart form of data received from the companies. These charts were the same used in reporting these findings. Each juror was required to exercise a judgment as to the aceptability (advisability or essentiality) of course distributions for each occupation found on the charts. The purpose of this evaluation, then, is to provide curricular patterns for the various occupations identified in this study. The criteria provided by this jury are as follows:

1. When the solid (essential) bar reaches the 40% gradient, the course represented by that bar should be considered essential to the curriculum. Therefore, when at least 40% of the respondents indicated that a course was essential preparation for the occupation, it is reasonable to assume that this course be made an essential program requirement in the curriculum.

2. When the striped (advisable) portion of the total bar reaches the 40% gradient, that course should be considered advisable. Therefore, when 40% of the respondents indicated that a course was either a desirable or at least advisable program requirement for the occupation, it would be reasonable to assume that the course be considered an advisable requirement in the curriculum.

3. It was recognized that in identifying the essential and advisable courses, there are other courses peculiar to industrial and individual needs. Therefore, for any course where the respondents exceeded the minimum 1.0% (necessary to be identified with a bar on the chart), it was assumed that these courses could be considered as technological curricular electives.

Interpretation of Data

General Curricular Observations

The most general conclusion to be drawn from the responses is that mathematics should be emphasized in all areas of technology. The majority of technical occupations require instruction in algebra, trigonometry, and geometry. Logarithms, including slide rule instruction, was strongly advised. In addition, many occupations required instruction in advanced geometry or calculus.

Chemical Technology For occupations in the general area of chemical technology, Figure 57, less emphasis was given to mathematics than for occupations in other areas of technology. Algebra, logarithms, and slide rule usage were essential, and trigonometry and plane geometry were strongly advised. Of course, strong emphasis was placed upon chemistry instruction. Courses in general chemistry, qualitative analysis, quantitative analysis, and organic chemistry were essential. Courses in physical chemistry and instrumental methods of analysis were advisable. Also advisable were courses in the analysis of experimental data and technical writing.

This summary represents only a basic program for the preparation of technicians in the general area of chemistry. Some occupations within this area require a more rigorous program than do others, demanding a more extensive mathematics background, some physics, and perhaps additional specialized courses.

Metal Technology Preparation for occupations in the general area of metal technology, Figure 58, should include a strong mathematics background. Algebra, trigonometry, and plane geometry were essential. Solid geometry was advisable and logarithms and slide rule usage were strongly advised. General chemistry (inorganic and metals) was essential, and qualitative analysis,

FIGURE 57: CHEMICAL TECHNOLOGY

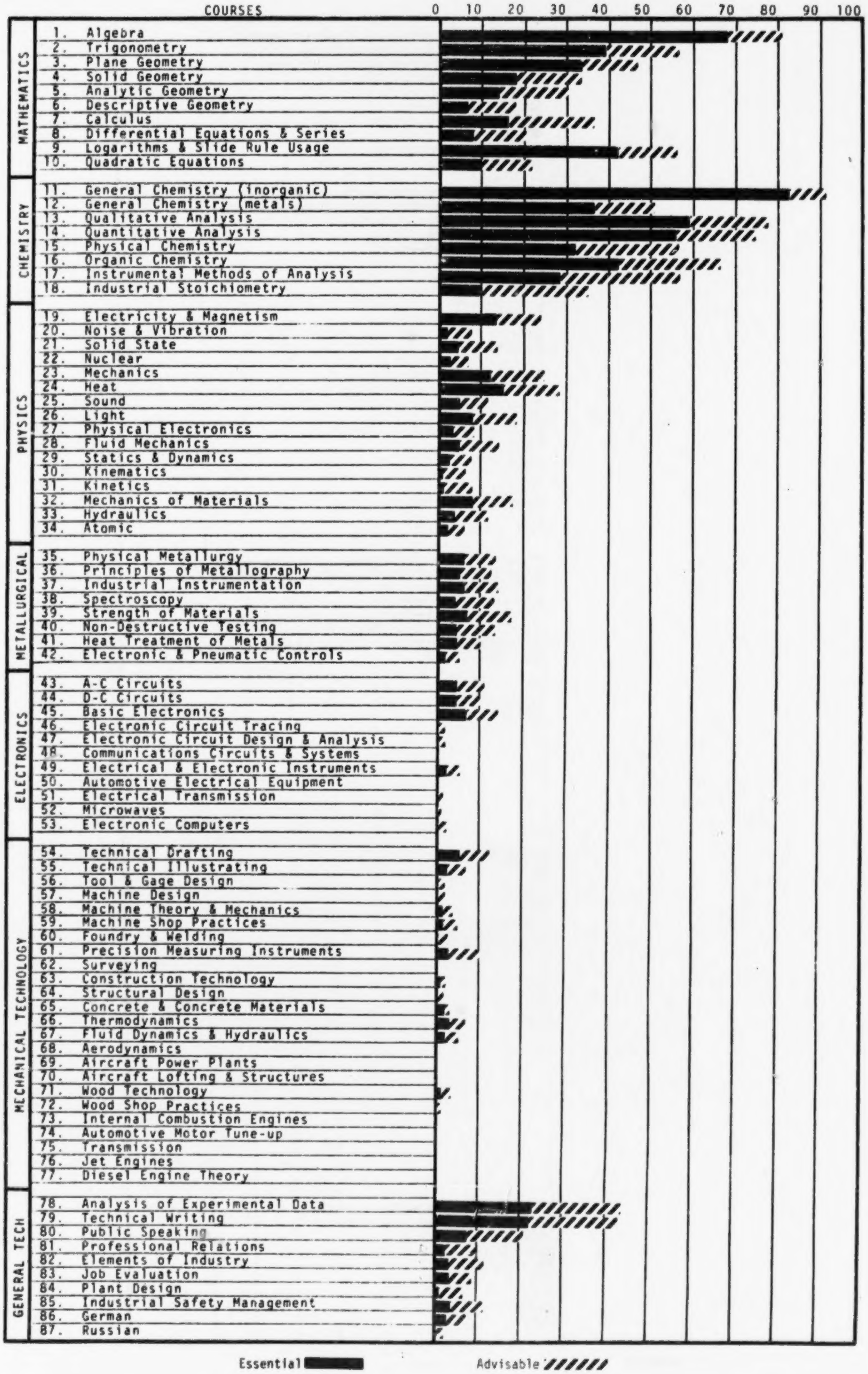
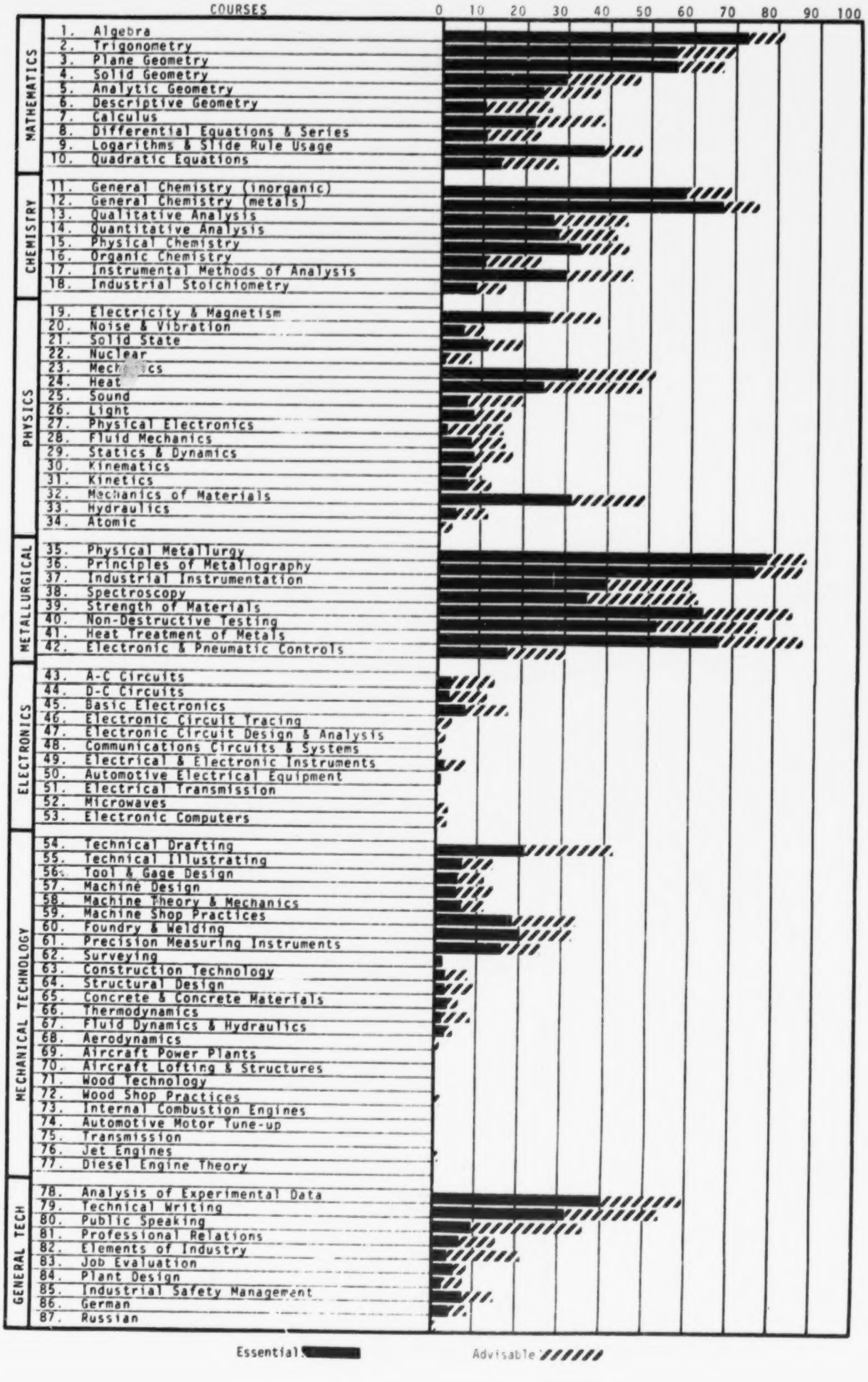


FIGURE 58: METAL TECHNOLOGY



quantitative analysis, physical chemistry, and instrumental methods of analysis were advisable, as well as physics instruction in mechanics, mechanics of materials, and heat. Other essential courses were physical metallurgy, principles of metallography, industrial instrumentation, strength of materials, nondestructive testing, heat treatment of metals, and analysis of experimental data. In addition, spectroscopy, technical drafting, and technical writing were advisable.

Electrical Technology The training needs in the general area of electrical technology, Figure 59, varied a great deal among the different occupations. In general, the use of algebra, trigonometry, plane geometry, logarithms, and slide rule usage were essential, and solid geometry was advisable. Physics instruction was essential in electricity and magnetism, and advisable in mechanics. Courses in AC circuits, DC circuits, basic electronics, electronic circuit tracing, and electrical and electronic instrumentation were essential. Courses in electronic circuit tracing, communications circuits and systems, and technical drafting were essential.

Mechanical Technology The essential mathematics courses for occupations in the general area of mechanical technology, Figure 60, were algebra, trigonometry, and plane geometry. Solid geometry and logarithms and slide rule usage were strongly advised, and analytic geometry was seen as advisable. In the area of physics, mechanics was advisable. Also, technical drafting and machine shop practices were deemed essential. Tool and gauge design, machine design, and machine theory and mechanics were deemed advisable.

Miscellaneous Technology The last section of occupations was identified as miscellaneous, Figure 61. While the number of responses was small as compared with those of the other major areas of mechanical, electrical,

FIGURE 59: ELECTRICAL TECHNOLOGY

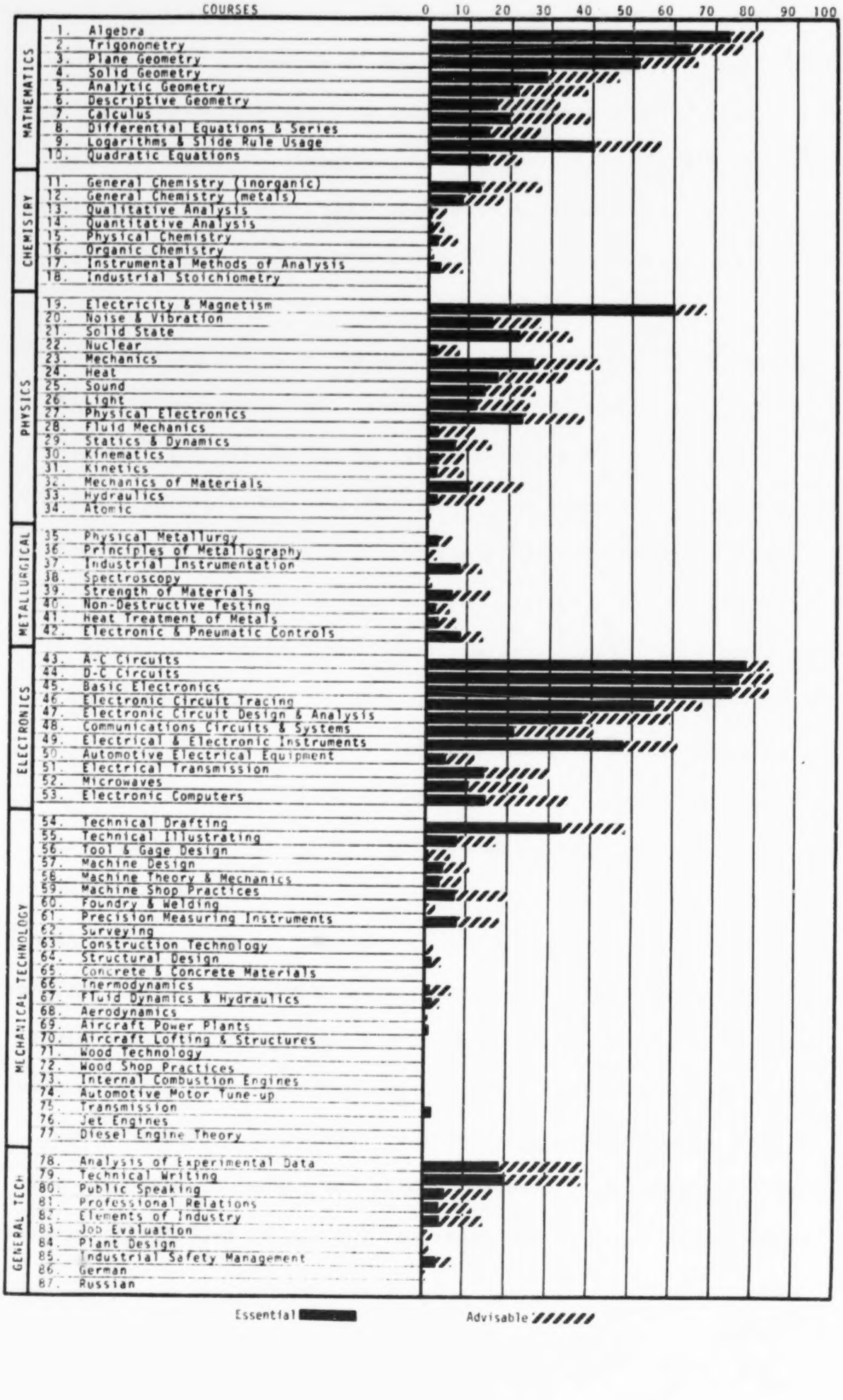


FIGURE 60: MECHANICAL TECHNOLOGY

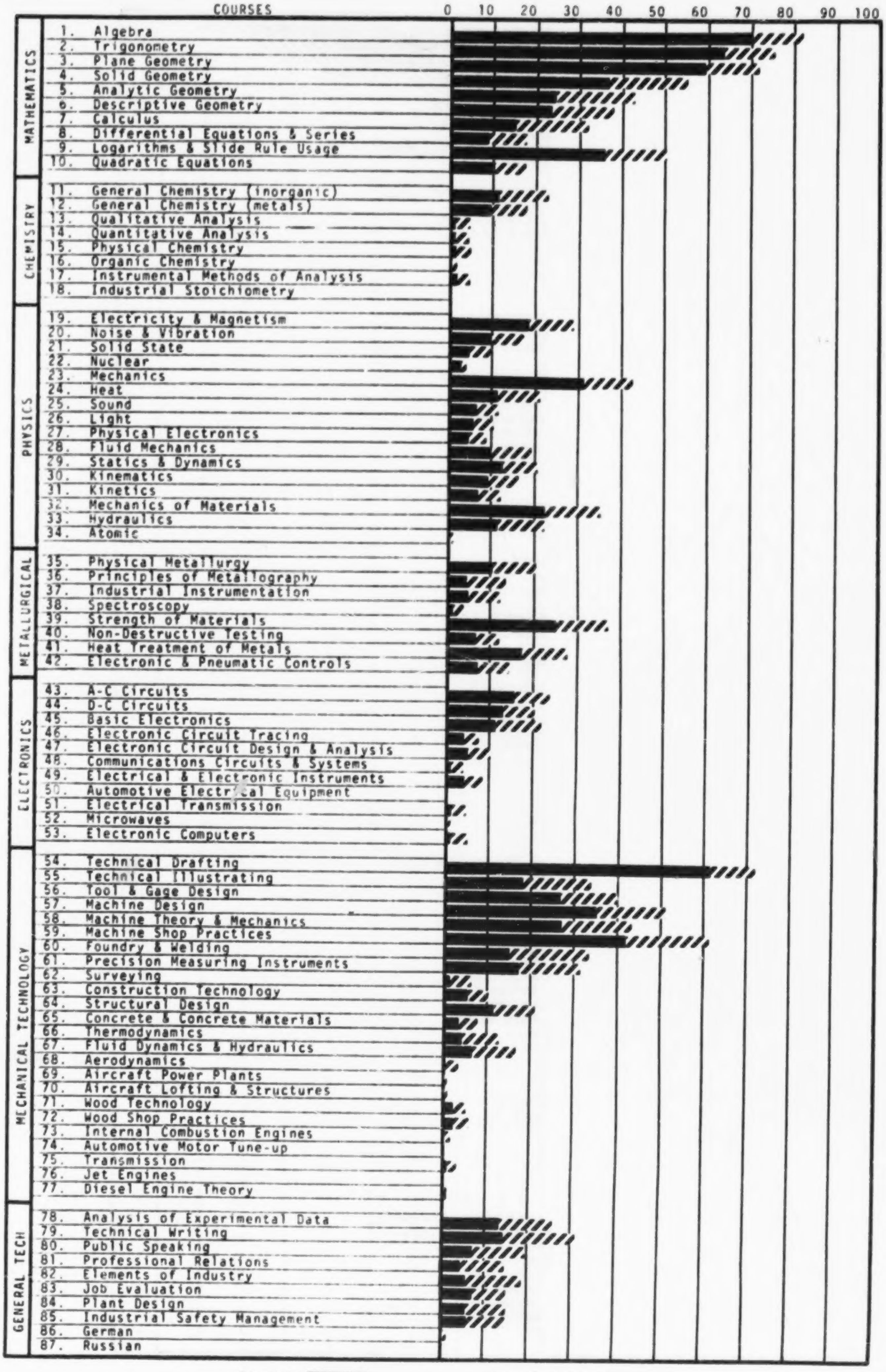
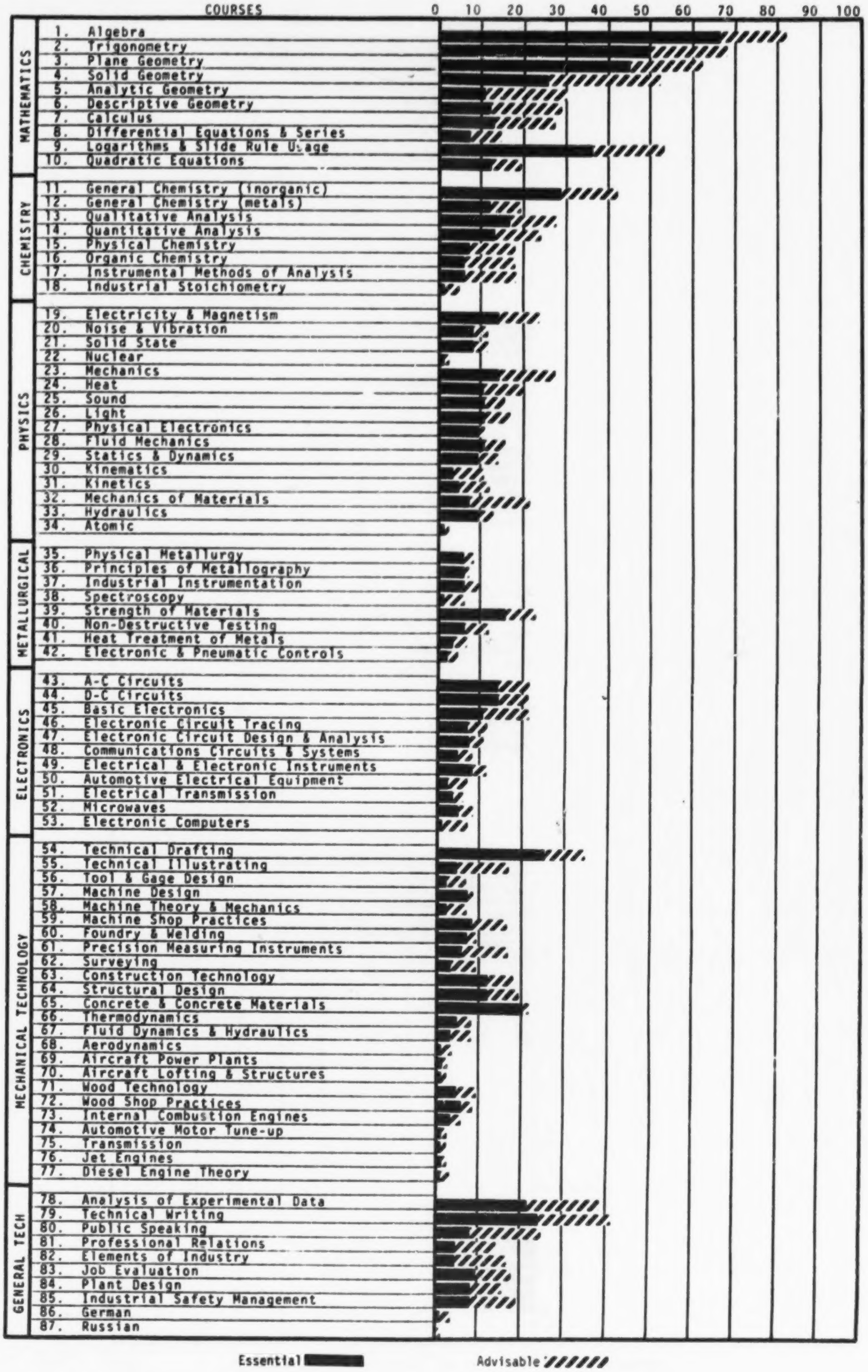


FIGURE 61: MISCELLANEOUS TECHNOLOGY



metal, and chemical technology, it is felt that a general statement is warranted here.

Approximately 50% of the responses in the Miscellaneous section of occupations could be identified as occurring in the emerging concept of industrial engineering. The remaining occupations in this Miscellaneous section varied in degree of responsibility, and might be termed appropriately, Miscellaneous Technologies. Therefore, the concept of industrial engineering, in addition to requiring a substantial amount of mathematical background in the areas of algebra, trigonometry, plane geometry, solid geometry, and analytic geometry, appeared to include the need for a comprehensive exposure in the areas of chemistry, physics, metallurgy, electronics, mechanical technology, and general technology.

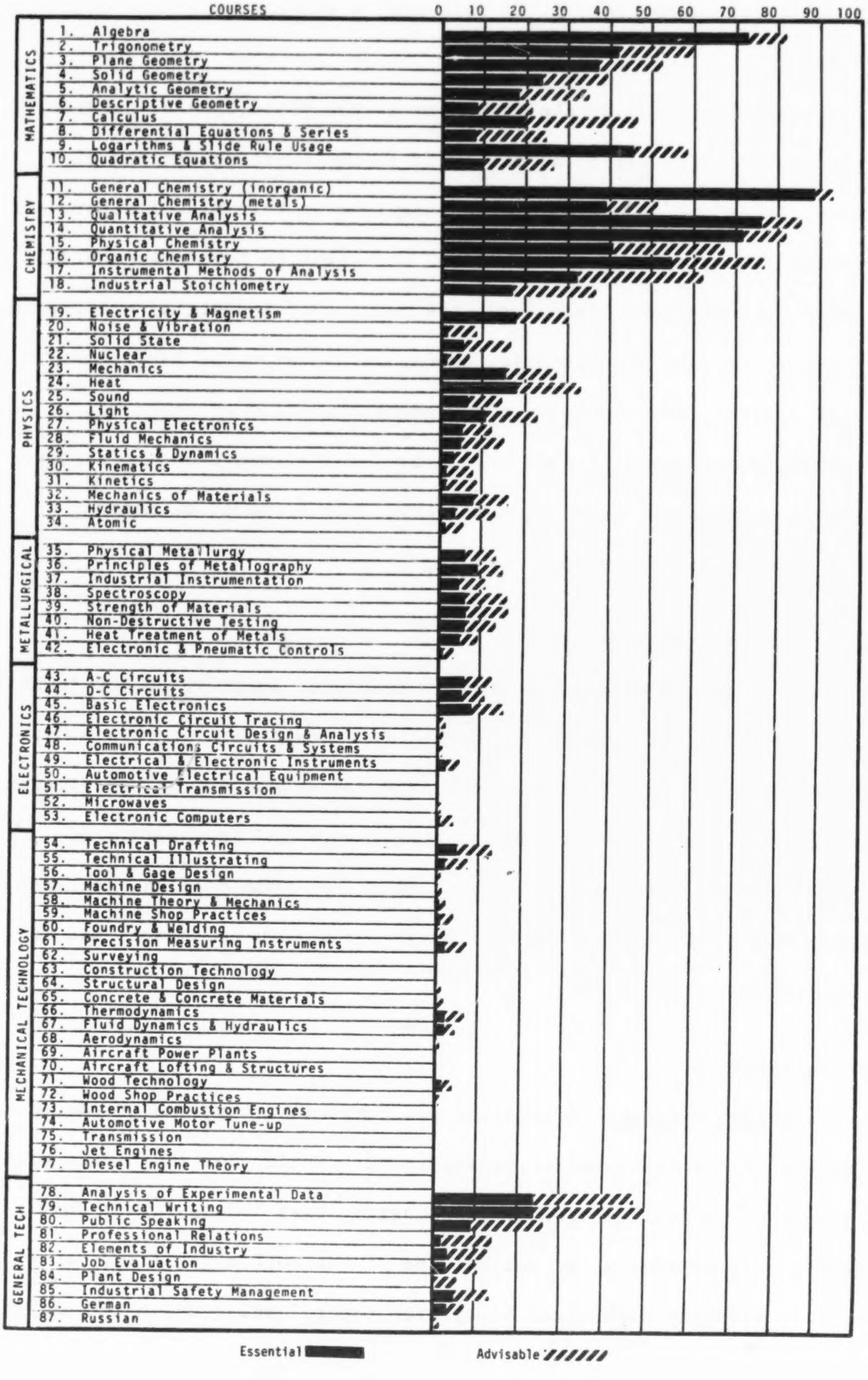
Specific Curricular Observations

This section includes the summary responses relative to the essential and advisable courses for each of the occupations dealt with in this study. Again, the mathematics tool is the predominant common subject in all programs. General stress was also placed on needed course work in the analysis of experimental data and technical writing. Otherwise, when dealing with specific occupations, there was a great deal of variation in both the amount and the kind of instruction felt needed.

(Chemical Technology)

Assistant Chemist A total of 183 companies exercised judgments with reference to Assistant Chemists, Figure 62. Their view indicated, with reference to the chemical technology in industry, that the Assistant Chemist's is one of the most demanding, as well as one of the most diversified, curricula. Mathematics is strongly emphasized along with upper level courses in chemistry.

FIGURE 62: ASSISTANT CHEMIST



Respondents felt that physics, technical writing, and analysis of experimental data are both essential and advisable courses for the technician. Metals and electrical technology were the preferred areas for elective courses.

The respondents felt that it was essential to have course work in mathematics, chemistry, and general technology. In the area of mathematics, algebra, trigonometry, plane geometry, logarithms and slide rule usage were essential courses for Assistant Chemists. In the area of chemistry, course work in general chemistry (inorganic) as well as qualitative analysis and quantitative analysis was deemed essential. In the area of general technology, it was felt that analysis of experimental data was an essential course for the program of an Assistant Chemist.

In addition to these essential courses, the respondents felt that course work in chemistry, physics, and general technology was advisable. In the chemical area, general chemistry (metals), physical chemistry, organic chemistry, and instrumental methods of analysis were advisable for Assistant Chemists. The specific course work deemed advisable in the area of physics included heat and mechanics of materials. In addition, it was felt advisable that Assistant Chemists should have instruction in technical writing.

The elective course work preferred by the respondents came within the general areas of mathematics, physics, metallurgy, and general technology. Specifically, in the area of mathematics, solid geometry, and analytic geometry were suggested electives. In the area of physics, mechanics was indicated as a preferred elective, and in metallurgy, industrial instrumentation and strength of materials were preferred. Public speaking was also an important elective for the Assistant Chemist.

Ceramics Technician Curricular recommendations were made by 39 companies for those preparing to work as Ceramics Technician, Figure 63. The curriculum identified by these recommendations was similar to that of the Assistant Chemist. The areas of instruction from which the essential technical courses were selected, included mathematics, chemistry, and general technology. The essential mathematics background consisted of algebra, trigonometry, plane geometry, and logarithms and slide rule usage. The needed chemistry courses were general chemistry (inorganic), qualitative analysis, and quantitative analysis. From the area of general technology, instruction in the analysis of experimental data was considered to be essential.

The respondents chose additional advisable course work from the areas of chemistry, physics, and general technology. Selected from the area of chemistry were courses in general chemistry (metals), physical chemistry, organic chemistry, and instrumental methods of analysis. The advisable physics instruction included heat and mechanics of materials. From the area of general technology, technical writing came within the advisable classification.

Of the remaining courses, respondents preferred as electives, courses in the general areas of mathematics, physics, metallurgy, and general technology. Solid geometry and analytic geometry were suggested from the area of mathematics. From the area of physics, mechanics was selected, along with industrial instrumentation and strength of materials from the area of metallurgy. Also preferred among the electives was a course in public speaking.

Chemical Technician, Radiation A total of 13 companies made judgments with reference to the curricular needs of the Chemical Technician, Radiation, Figure 64. They recommended a relatively demanding curriculum which included upper-level courses in mathematics, chemistry, and physics, as well as courses

FIGURE 63: CERAMICS TECHNICIAN

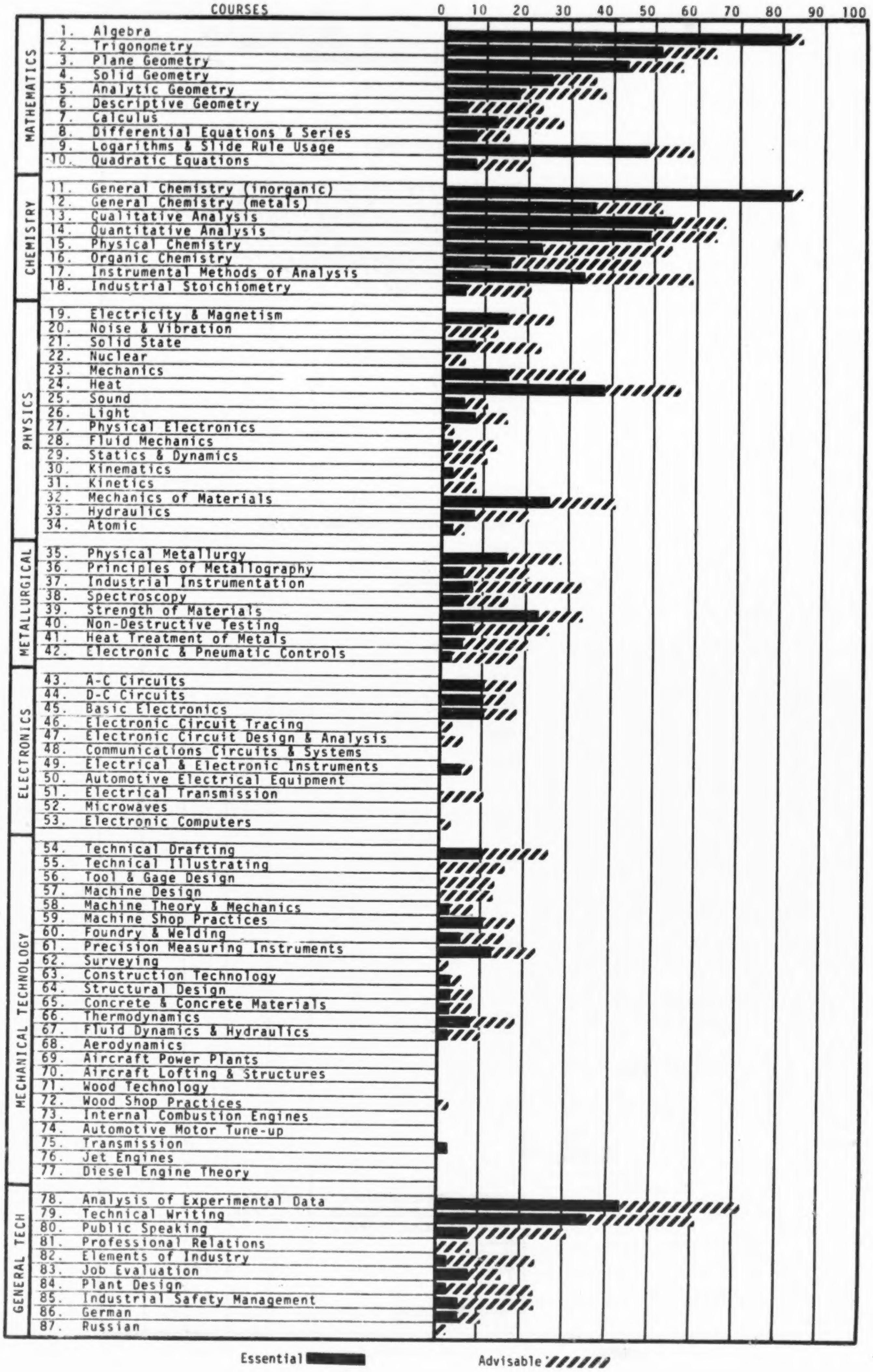
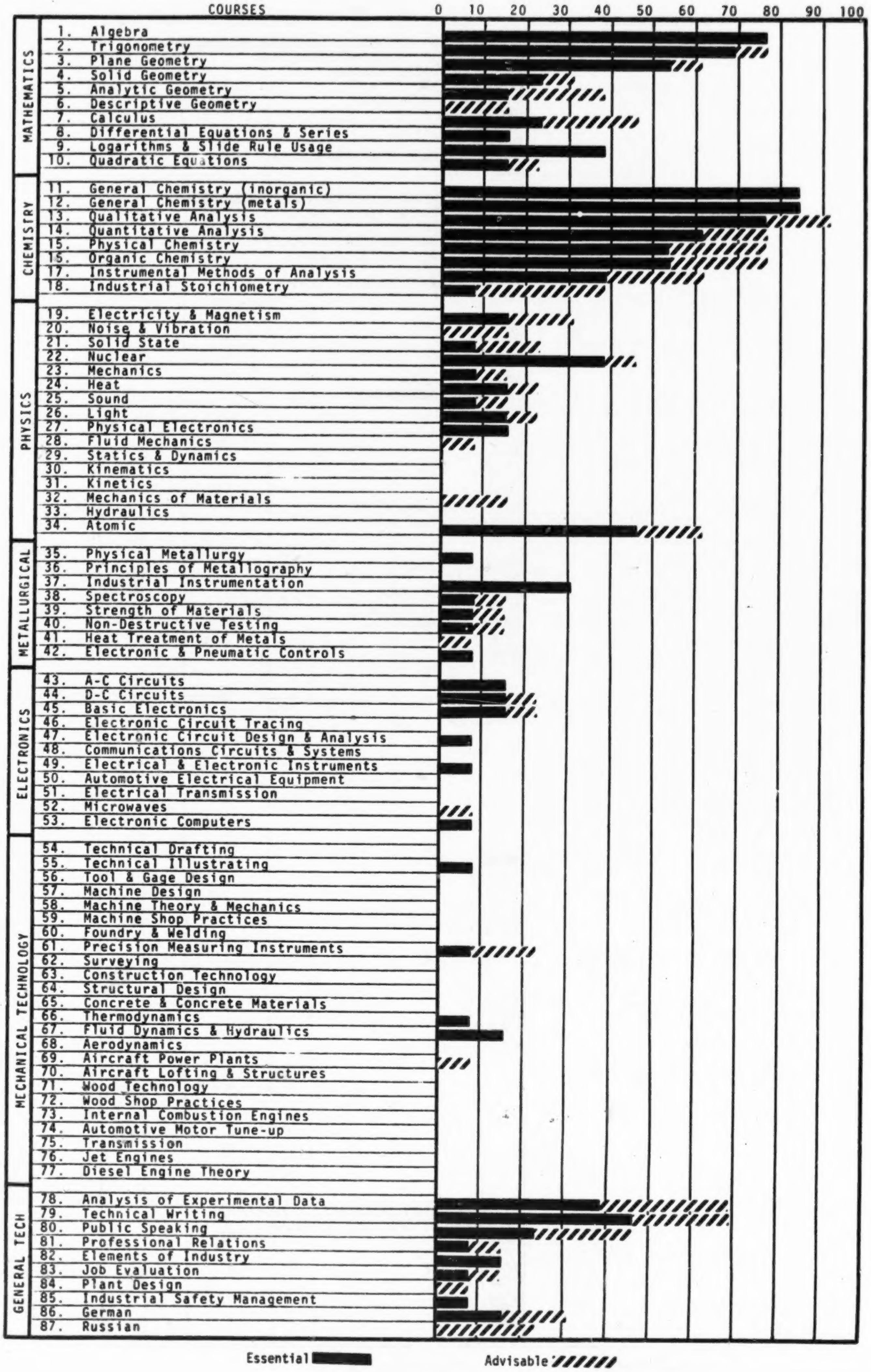


FIGURE 64: CHEMICAL TECHNICIAN, RADIATION



in general technology. In addition, they suggested elective course work in the area of metallurgy.

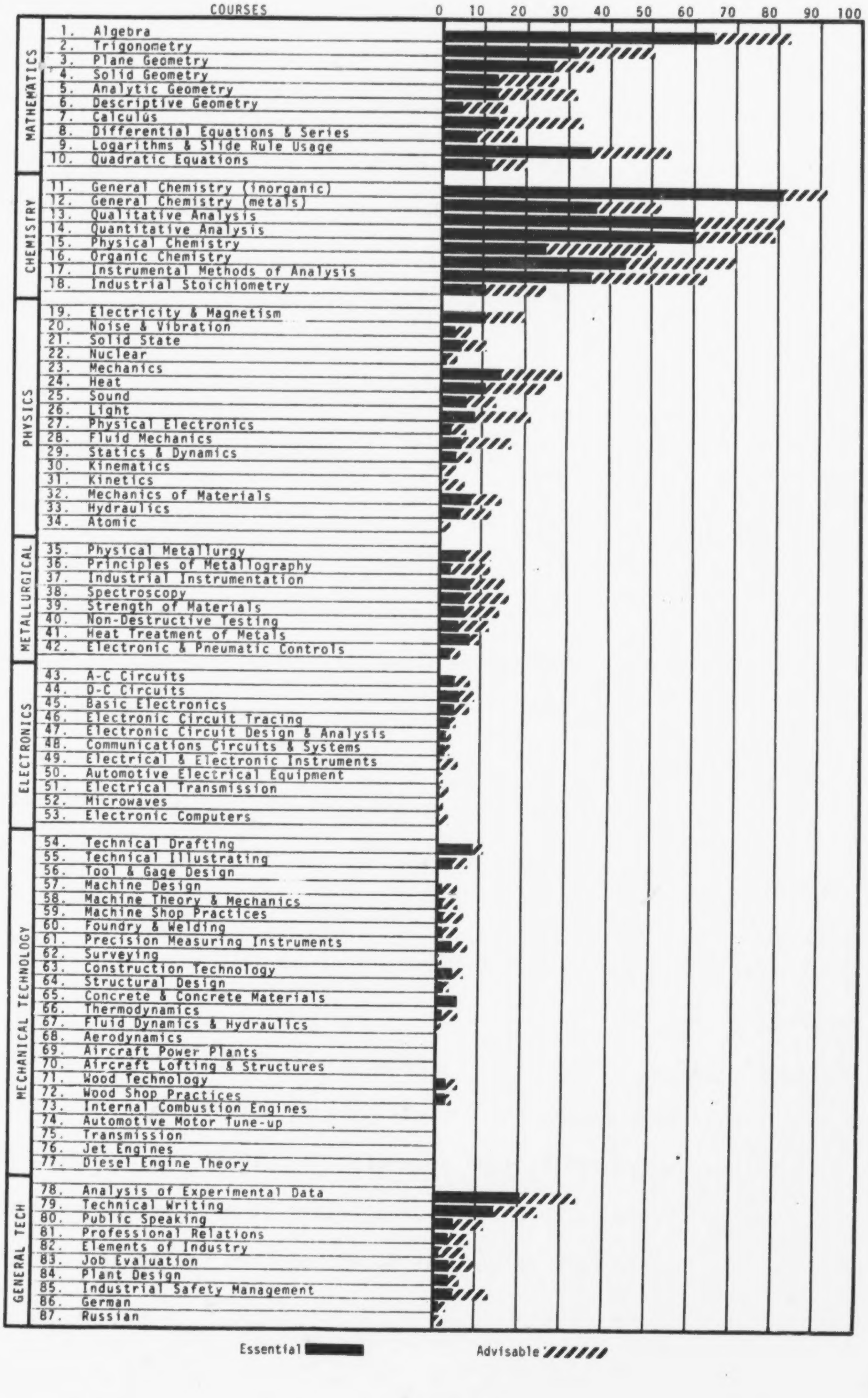
The required mathematics background for the Chemical Technician, Radiation, includes algebra, trigonometry, and plane geometry. The essential background in chemistry includes general chemistry (both inorganic and metals), qualitative analysis, quantitative analysis, physical chemistry, and organic chemistry. Atomic physics and technical writing were also considered to be essentials.

Mathematics course work in calculus was advised by the responding companies. In addition to the many courses already indicated as essentials within the area of chemistry, industrial methods of analysis was considered advisable. Other courses advised for the Chemical Technician, Radiation, were nuclear physics, analysis of experimental data, and public speaking.

The preferred electives for the Chemical Technician, Radiation, came within the general areas of mathematics, chemistry, physics, metallurgy, and general technology. In mathematics, solid geometry, analytic geometry, logarithm and slide rule usage were suggested electives. In the area of chemistry, industrial stoichiometry was suggested. In the area of physics, electricity and magnetism was considered a preferred elective. One course in the area of metallurgy, industrial instrumentation, as well as course work in German, was suggested.

Control Analyst A total of 84 companies indicated their curricular judgments with regard to training for Control Analyst, Figure 65. The curriculum which they suggested is less demanding than those indicated above. The needed course work comes within the general areas of mathematics and chemistry, and in addition, the course work in general technology was considered elective.

FIGURE 65: CONTROL ANALYST



In the area of mathematics, only algebra was considered essential. However, the Control Analyst needed several courses in the general area of chemistry. These included general chemistry (inorganic), qualitative analysis, quantitative analysis, and organic chemistry.

The advisable mathematics courses were trigonometry and logarithm and slide rule usage. A few additional courses in the area of chemistry were advised including general chemistry (metals), physical chemistry, and instrumental methods of analysis.

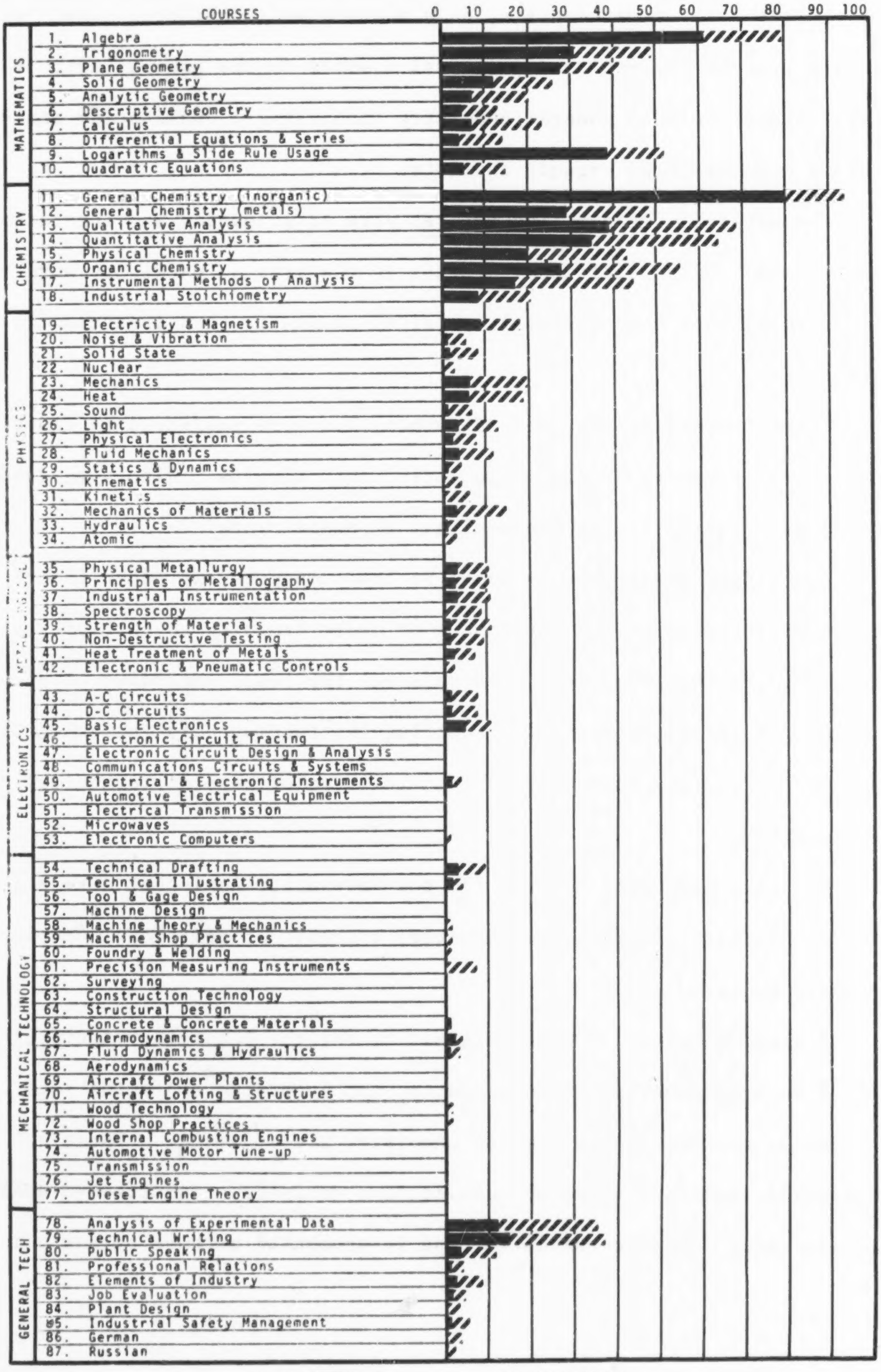
Three courses in the area of mathematics were preferred as electives. These were plane geometry, analytic geometry, and calculus. Also suggested as an elective was instruction in the analysis of experimental data.

Laboratory Assistant A total of 164 companies expressed their preferences with regard to the curriculum of those training to be Laboratory Assistants, Figure 66. They felt that this was the least demanding curriculum in the area of chemical technology, requiring instruction only in mathematics and chemistry. However, some electives in the area of general technology were also desired.

The only essential courses for the Laboratory Assistant were algebra and general chemistry (inorganic). However, a number of additional courses were strongly advised.

Advisable course work in mathematics for the Laboratory Assistant should include trigonometry, plane geometry, and logarithm and slide rule usage. Several courses in the area of chemistry are advisable. These would include general chemistry (metals), qualitative analysis, quantitative analysis, physical chemistry, organic chemistry, and instrumental methods of analysis.

FIGURE 66: LABORATORY ASSISTANT



The preferred electives for the Laboratory Assistant came within the area of general technology. These were courses in the analysis of experimental data and technical writing.

Research Laboratory Analyst A total of 66 different companies expressed their desires with regard to the training of Research Laboratory Analyst, Figure 67. This is a rigorous curriculum demanding a solid mathematics background and advanced course work in the area of chemistry, as well as some courses in the area of general technology.

The essential mathematics background should include algebra, trigonometry, and logarithms and slide rule usage. In addition, several courses in the area of chemical technology are required. These include general chemistry (both inorganic and metals), qualitative analysis, and quantitative analysis. In terms of their required instruction in the area of chemistry, this is the most demanding curriculum.

The two advisable courses in the area of mathematics are plane geometry and calculus. The Research Laboratory Analyst should also take course work in the area of general technology. Specifically, these courses should be analysis of experimental data and technical writing.

The desired electives for the Research Laboratory Analyst fell within the general area of mathematics. These included courses in solid geometry, analytic geometry, and fiferential equations and series.

(Metal Technology)

Assistant Metallurgist A total of 71 companies exercised judgments, with reference to Assistant Metallurgist, Figure 68. While the general emphasis was on course work in mathematics and metallurgy, their responses indicated a

FIGURE 67: RESEARCH LABORATORY ANALYST

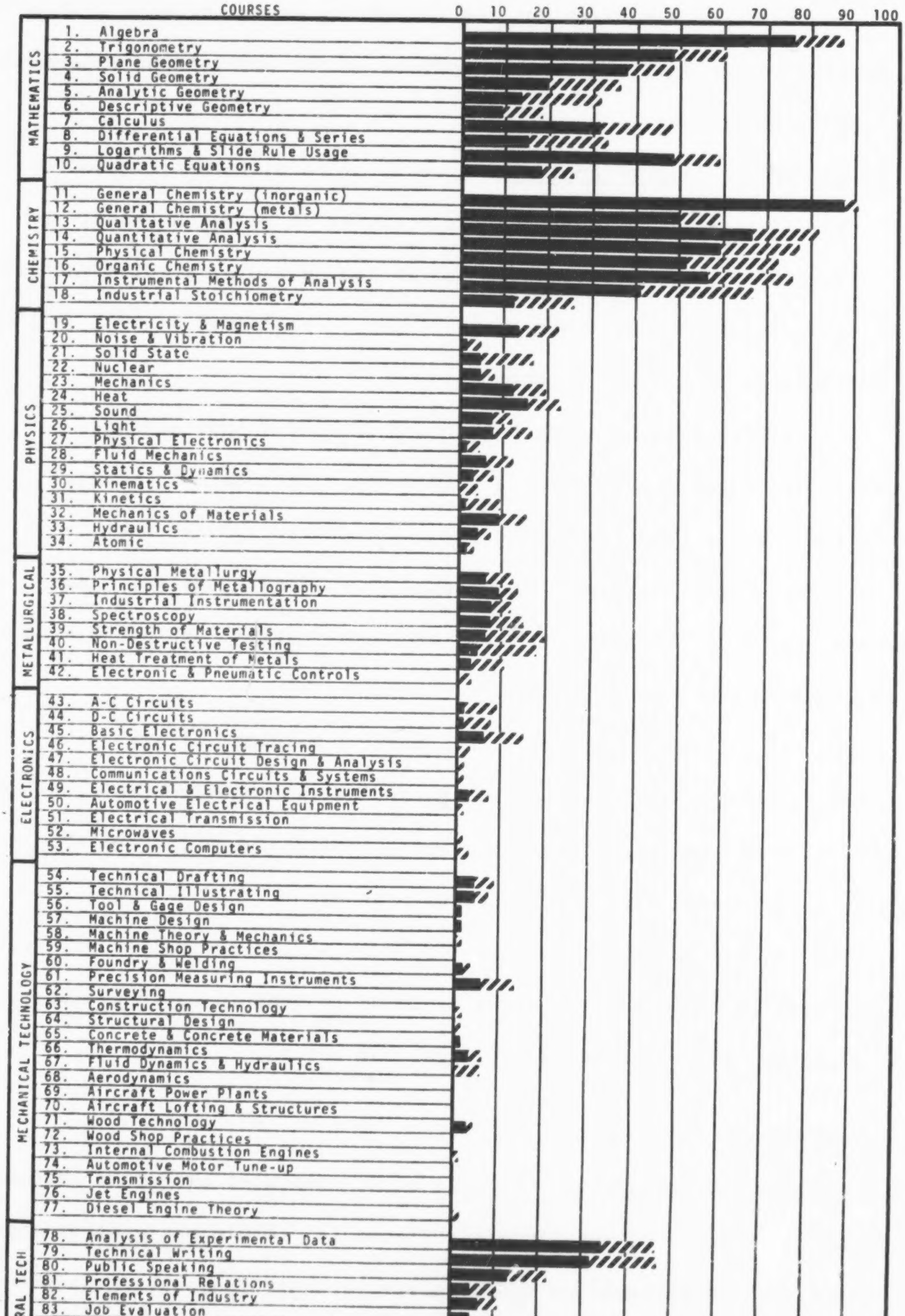
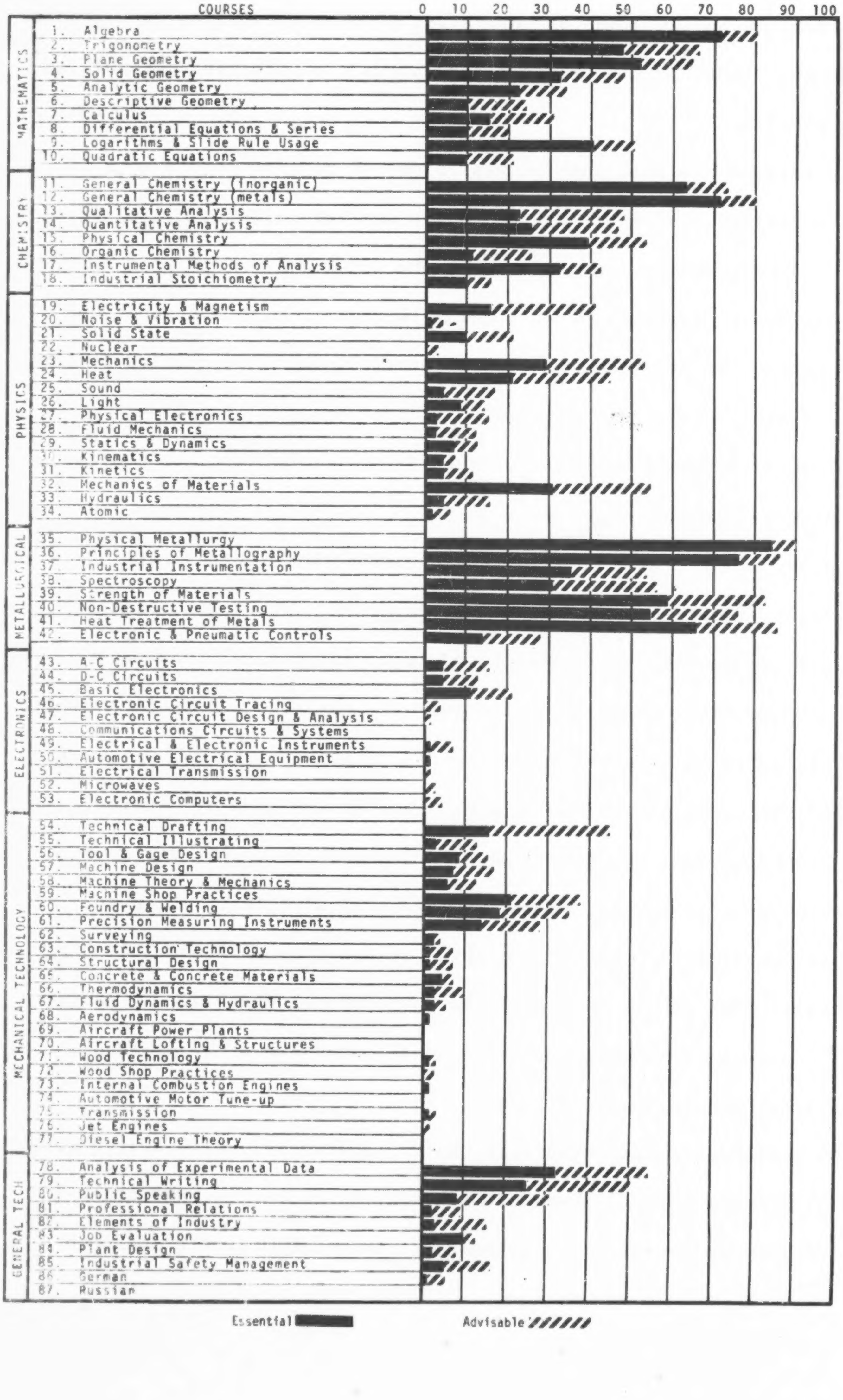


FIGURE 68: ASSISTANT METALLURGIST



need for instruction in the areas of chemistry, physics, mechanics, and general technology, also. Thus, this represents a relatively diversified, as well as rigorous, curriculum.

The respondents felt that it was essential to have course work in mathematics, chemistry, and metallurgy. In the area of mathematics, algebra, trigonometry, plane geometry, and logarithms and slide rule usage were considered essential. Instruction in general chemistry (both inorganic and metals) was needed. In addition, there were several essential courses in the general area of metallurgy. These courses included physical metallurgy, principles of metallography, strength of materials, non-destructive testing, and heat treatment of metals.

The advisable course work for the Assistant Metallurgist as indicated by the respondents included a greater number of areas including mathematics, chemistry, physics, metals, mechanical technology, and general technology. The advisable course in mathematics was solid geometry, and the advisable courses in chemistry included qualitative analysis, quantitative analysis, physical chemistry, and instrumental methods of analysis. In the area of physics, electricity and megnetism, mechanics, heat, and mechanics of materials were advised. In the area of metals, it was advisable to have instruction in industrial instrumentation and spectroscopy. In the area of mechanics, the Assistant Metallurgist should have a course in technical drafting. Finally, in the area of general technology, courses in the analysis of experimental data and technical writing were advised.

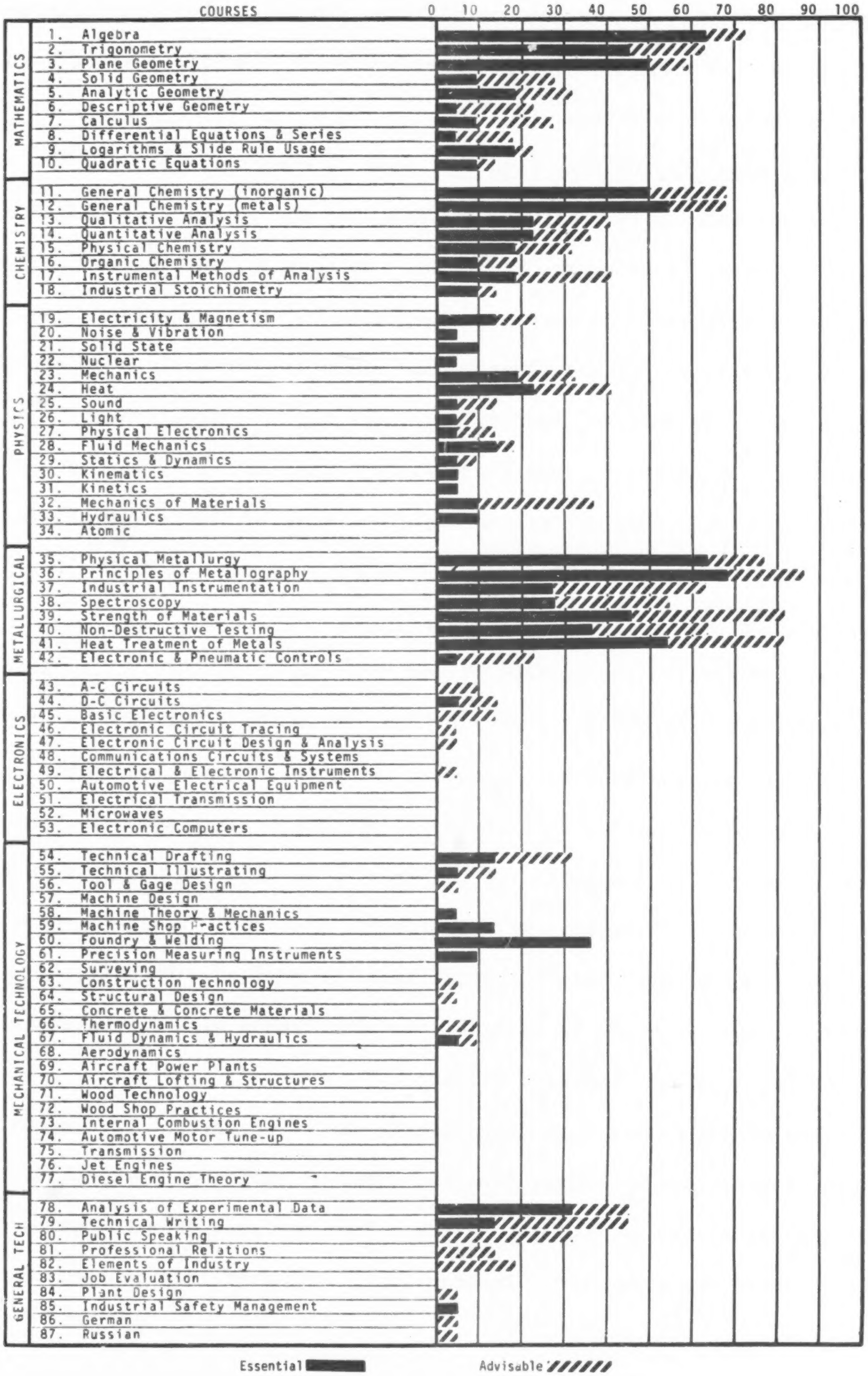
The respondents indicated that their preferred elective course work should come within the general areas of mathematics, mechanics, and general technology. First, in the area of mathematics, they would prefer analytic geometry and calculus. In the area of mechanics, machine shop practices and foundry welding were suggested as electives. Finally, public speaking was considered a desirable elective.

Laboratory Technician, Foundry Some 22 companies reported their curricular preferences with regard to training for the position of Laboratory Technician, Foundry, in industry, Figure 69. Once again, the desired course work includes a sampling from many general areas, but the emphasis is upon mathematics, chemistry, and metallurgy. The essential mathematics background for the Laboratory Technician, Foundry, includes algebra, trigonometry, and plane geometry. In addition, general chemistry (both inorganic and metals) was considered essential. This technician must have several courses in metals. These would include physical metallurgy, principles of metallography, strength of materials, and heat treatment of metals.

In addition to the courses listed above which the Laboratory Technician, Foundry, must have, there are a number of courses in the areas of chemistry, physics, metallurgy, and general technology which this technician should have. Within the area of chemistry, this would include qualitative analysis, and instrumental methods of analysis. In the area of physics, it would include instruction in heat. In metallurgy, courses in industrial instrumentation, spectroscopy, and non-destructive testing would be advised. Finally, in general technology, it would be advisable to have course work in the analysis of experimental data and technical writing.

The electives which the respondents preferred for the Laboratory Technician, Foundry, were courses from the areas of mathematics, chemistry, physics, mechanics, and general technology. From the area of mathematics, analytic geometry was suggested. In chemistry, they preferred courses in

FIGURE 69: LABORATORY TECHNICIAN, FOUNDRY



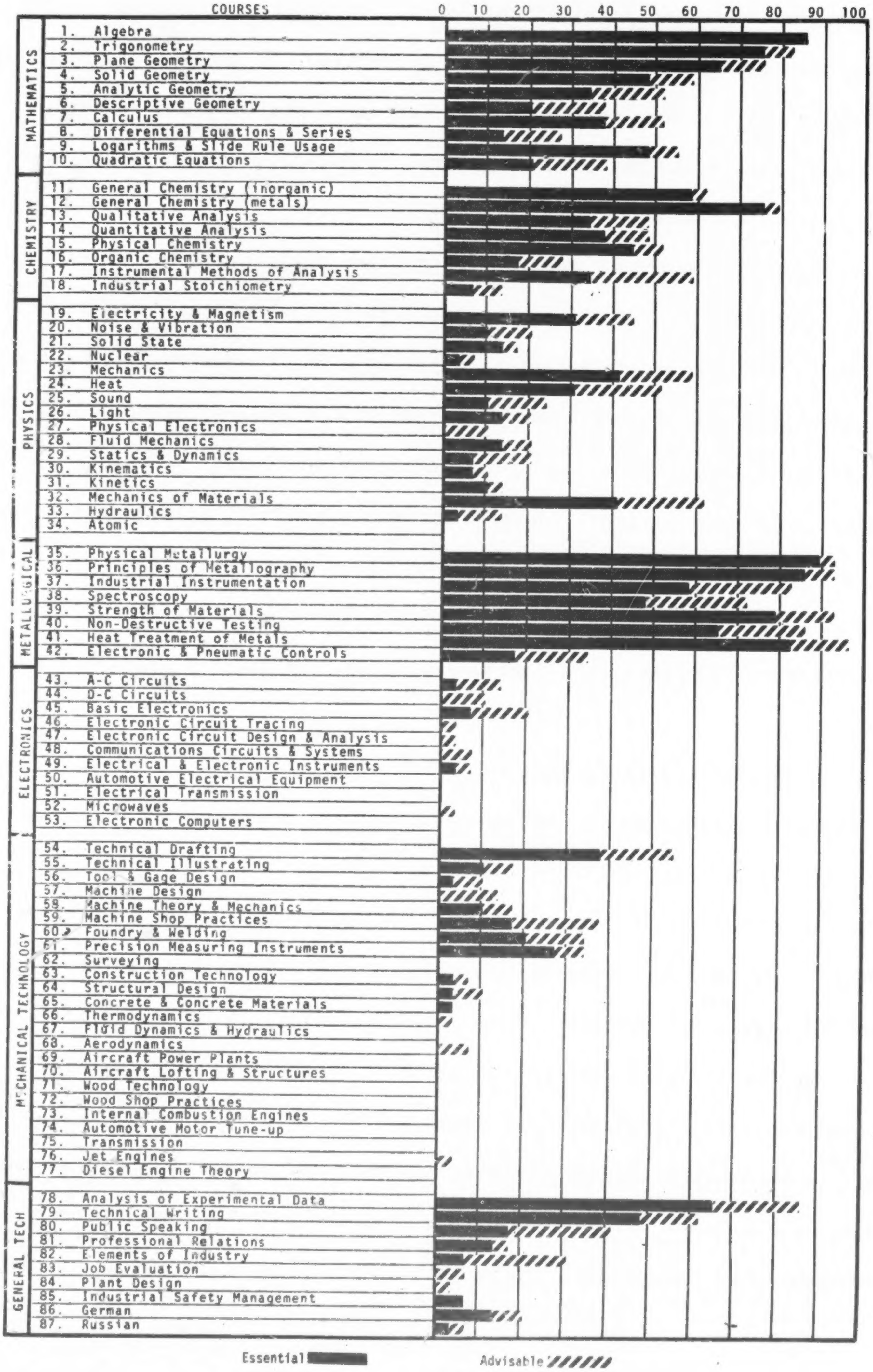
quantitative analysis and physical chemistry. In physics, the suggested electives were mechanics and mechanics of materials. In mechanical technology, the desired electives were course work in technical drafting and foundry and welding, and finally, in the area of general technology, public speaking was selected by the respondents.

Research Laboratory Analyst (Extractive Metallurgy) Some eight companies responded with regard to the Research Laboratory Analyst (Extractive Metallurgy). They required for this occupation a basic background in mathematics, general chemistry, general technology courses in analysis of experimental data and technical writing, and a strong concentration on courses in the area of metallurgy. The metallurgical course work would include physical metallurgy, principles of metallography, industrial instrumentation, spectroscopy, strength of materials, non-destructive testing, and heat treatment of metals. In addition, some instruction in physics and more advanced mathematics and chemistry would be advised.

Research Laboratory Analyst (Physical Metallurgy) A total of 29 companies made recommendations with regard to the curricular needs for the Research Laboratory Analyst (Physical Metallurgy) in industry, Figure 70. They indicated that this was the most rigorous curriculum within the area of metal technology. Mathematics training through calculus was strongly advised, as well as advanced courses in chemistry, physics, metallurgy, and some general technology.

The essential background in mathematics included algebra, trigonometry, plane geometry, solid geometry, and logarithm and slide rule usage. In addition, instruction in general chemistry (both inorganic and metals) as well as physical chemistry was needed. In the area of physics, mechanics and mechanics of materials were considered as essentials. There were several essential courses indicated

FIGURE 70: RESEARCH LABORATORY ANALYST (PHYSICAL METALLURGY)



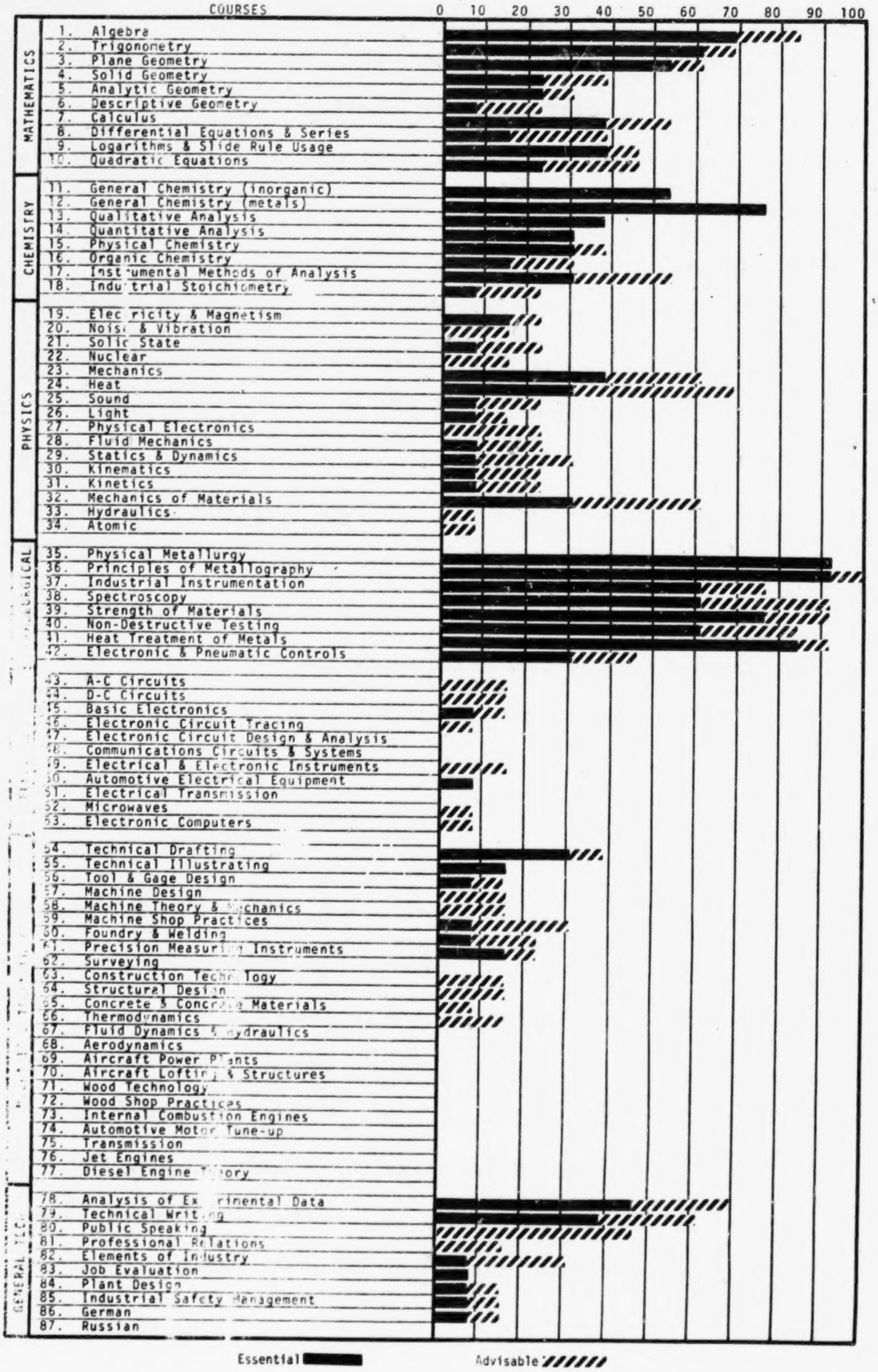
within the area of metallurgy. These included physical metallurgy, principles of metallography, industrial instrumentation, spectroscopy, strength of materials, non-destructive testing, and heat treatment of metals. In general technology, course work in the analysis of experimental data and technical writing were considered essential.

Additional advisable courses for the Research Laboratory Analyst (Physical Metallurgy) were selected from the general areas of mathematics, chemistry, physics, mechanics, and general technology. The two courses in mathematics considered advisable were analytic geometry and calculus. Chemistry courses in qualitative analysis, quantitative analysis, and instrumental methods of analysis were considered advisable. In the area of physics, courses in electricity and magnetism and heat were advised. Within the area of mechanics, technical drafting was strongly advised. Finally, within the area of general technology, public speaking was considered advisable.

Several courses were suggested as preferred electives. First of all, in the area of mathematics, quadratic equations and descriptive geometry were so indicated. In metallurgy, electronic and pneumatic controls was deemed an elective course of instruction. In the area of mechanics, there were three suggested electives which included machine shop practices, foundry and welding, and precision measuring instruments. A general technology course, elements of industry, was also deemed an elective for consideration.

Assistant Metallurgist, Metal Crystallization The 13 companies which responded with regard to this curriculum, indicated that the instruction needs for Assistant Metallurgist, Metal Crystallization, Figure 71, were very similar to that of the Assistant Metallurgist. In the present case, however, emphasis was placed upon the advanced metal technology courses. Once again, the needed

FIGURE 71: ASSISTANT METALLURGIST, METAL CRYSTALLIZATION



course work was selected from the general areas of mathematics, chemistry, physics, metallurgy, and general technology.

A basic mathematics background was considered essential, including courses in algebra, trigonometry, and plane geometry. Also essential was a basic background in general chemistry (both inorganic and metals). A number of courses from the area of metallurgical technology were considered essential. These include course work in physical metallurgy, principles of metallography, industrial instrumentation, spectroscopy, strength of materials, non-destructive testing, and heat treatment of metals. In addition, a course in the analysis of experimental data was considered to be essential.

It was advisable for the Assistant Metallurgist, Metal Crystallization, in industry to have a mathematics background which included courses in calculus, logarithms and slide rule usage, and quadratic equations. Also advised was a chemistry course in instrumental methods of analysis. The advised physics training included instruction in mechanics, heat, and mechanics of materials. One additional course in the area of metals was advised, in electronic and pneumatic controls. The Assistant Metallurgist, Metal Crystallization, should also have course work in technical writing and public speaking.

In addition to the needs indicated above, the respondents indicated a number of preferred electives for the Assistant Metallurgist, Metal Crystallization. These could include mathematics training in solid geometry, analytic geometry, and differential equations and series. Also considered as elective were chemistry courses in quantitative analysis, qualitative analysis, physical chemistry, and organic chemistry. In the area of physics, statics and dynamics was suggested as an elective. The suggested electives in mechanical technology were technical drafting and machine shop practices. Finally from the area of general technology, elements of industry was also suggested.

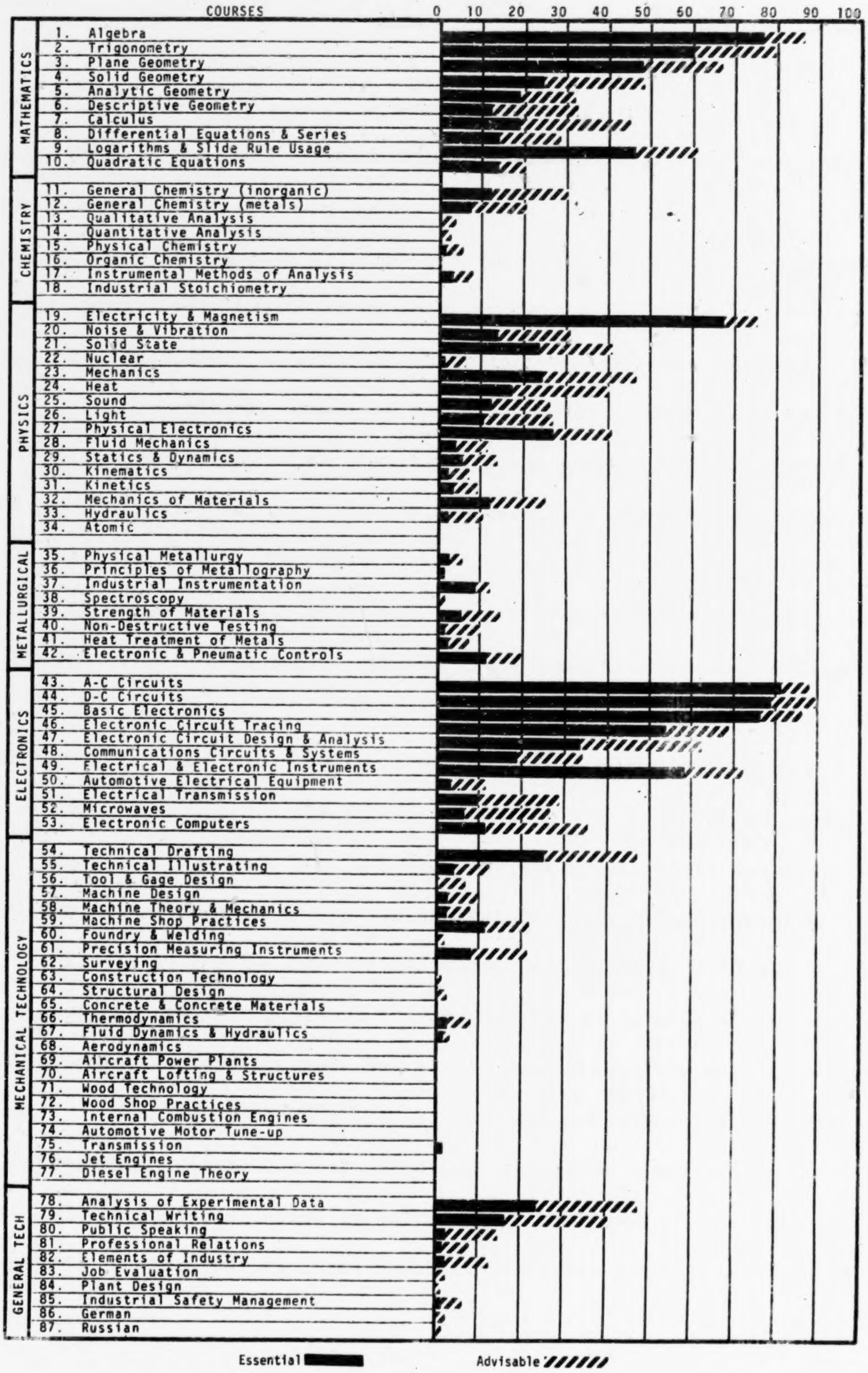
(Electrical Technology)

Electrical Test Development Technician A total of 121 companies expressed their judgments with regard to the technical training needs of the Electrical Test Development Technician in industry, Figure 72. They placed special emphasis upon the areas of mathematics and electricity and electronics. Also needed was instruction in the areas of physics, mechanics, and general technology.

The mathematics background considered essential by the respondents included courses in algebra, trigonometry, plane geometry, and logarithms and slide rule usage. They felt that it was also essential to have physics training in electricity and magnetism. From the area of electricity and electronics, they selected several courses as essentials. These included AC circuits, DC circuits, basic electronics, electronics circuit tracing, and electrical and electronic instruments.

Advisable course work for the Electrical Test Development Technician would include additional courses from the area of mathematics, physics, and electricity and electronics, plus others from the areas of mechanical technology and general technology. First of all, in the area of mathematics, solid geometry and calculus were considered advisable. In the general area of physics, it was advisable to have instruction in solid state mechanics, heat, and physical electronics. A course in electronic circuit design and analysis was also advisable for this curriculum. From the area of mechanical technology, technical drafting was considered an advisable course, and from the area of general

FIGURE 72: ELECTRICAL TEST DEVELOPMENT TECHNICIAN



technology, it was advisable to have instruction in the analysis of experimental data and technical writing.

The course work which the respondents indicated as preferred electives for this curriculum came from the areas of mathematics, chemistry, physics, and electricity and electronics. The two courses from the area of mathematics were analytic and descriptive geometry. General chemistry (inorganic) was indicated to be a preferred elective, as was instruction in noise and vibration in the area of physics. From the area of electricity and electronics, communications circuits and systems and electronic computers were the suggested electives.

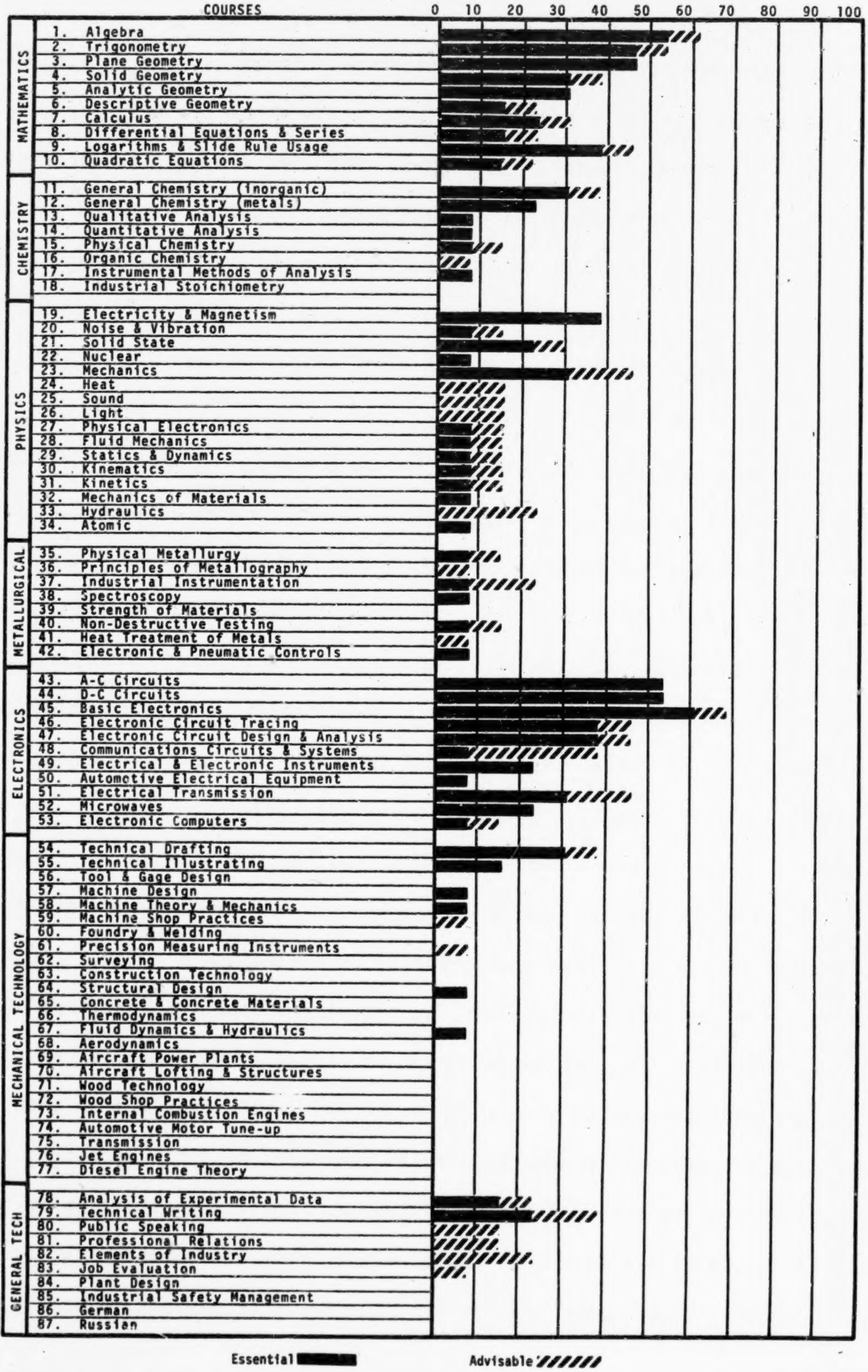
X-Ray Equipment Development Technician There were 13 responding companies which made curricular judgments with regard to the preparation of X-Ray Equipment Development Technician for industry, Figure 73. Their responses indicated this to be a relatively specialized program requiring instruction in the areas of mathematics and electricity. There were, however, other areas of technology represented among the electives.

The courses from the area of mathematics considered as essential were algebra, trigonometry, and plane geometry. The essentials selected from the area of electricity were AC circuits, DC circuits, and basic electronics.

The instruction considered advisable for this curriculum was within the general areas of mathematics, physics, and electricity and electronics. Logarithms and slide rule usage was the advised course in the mathematics area, and mechanics was the advised instruction in the area of physics. Also included from the area of electricity and electronics were courses in electronic circuit tracing, electronic circuit design and analysis, and electrical transmission.

A number of courses were indicated to be preferred electives by the responding companies. These courses were found to be in the areas of mathematics,

FIGURE 73: X-RAY EQUIPMENT DEVELOPMENT TECHNICIAN

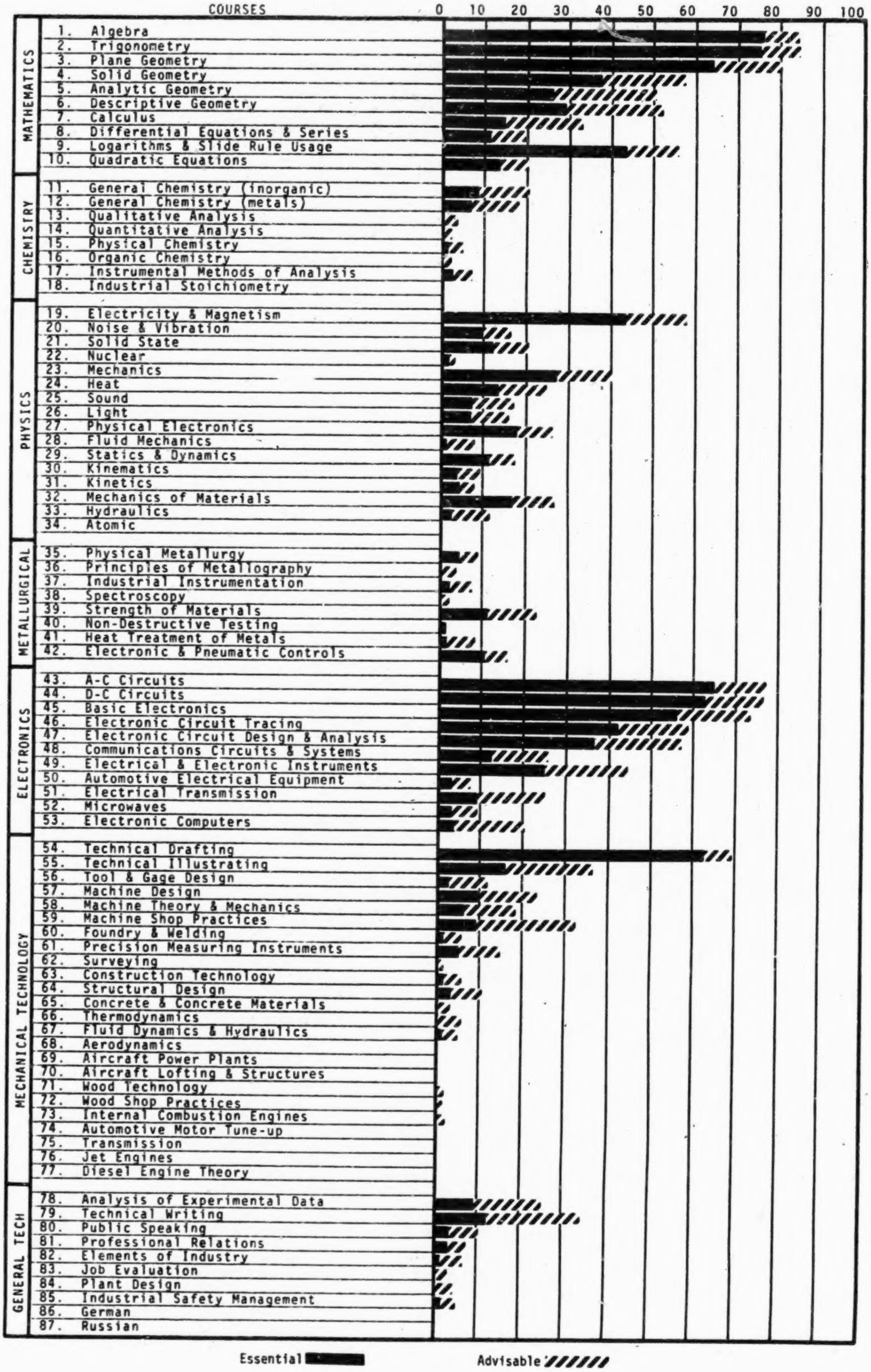


chemistry, physics, electricity and electronics, mechanics, and general technology. Three mathematics electives were indicated: solid geometry, analytic geometry, and calculus. General chemistry (inorganic) was also a suggested elective. Physics instruction in electricity and magnetism and solid state was considered to be elective. Other courses coming within the elective classification were communications, circuits and systems from the area of electricity and electronics, technical drafting from the area of mechanics, and technical writing from the area of general technology.

Design Draftsman, Electrical A total of 130 companies indicated their curricular judgments with regard to the training of Design Draftsman, Electrical, Figure 74. Once again, the selected curriculum emphasized the areas of mathematics and electricity and electronics. Course work from the areas of physics, mechanics, and general technology was also included in this curriculum. The respondents felt that it was essential to have course work in mathematics, physics, electricity and electronics, and mechanics. The required mathematics courses were algebra, trigonometry, plane geometry, and logarithms and slide rule usage. In the area of physics, it was deemed essential to have instruction in electricity and magnetism. The electricity and electronics courses which must be included were AC circuits, DC circuits, basic electronics, and electronic circuit tracing. In addition, from the area of mechanics, technical drafting was considered essential.

Several additional courses from the areas of mathematics, physics, and electricity and electronics were shown to be advisable additions to this curriculum. First, from the area of mathematics, solid geometry, analytic geometry, and descriptive geometry were considered advisable. Physics instruction in mechanics should be included, and from the area of electricity and electronics, electronic circuit design and analysis, and electrical and electronic instruments were deemed advisable.

FIGURE 74: DESIGN DRAFTSMAN, ELECTRICAL



Four other courses were preferred as electives. First, from the area of mathematics, calculus was suggested. From the area of mechanics, technical illustrating and machine shop practices were suggested. From the area of general technology, instruction in technical writing was also included.

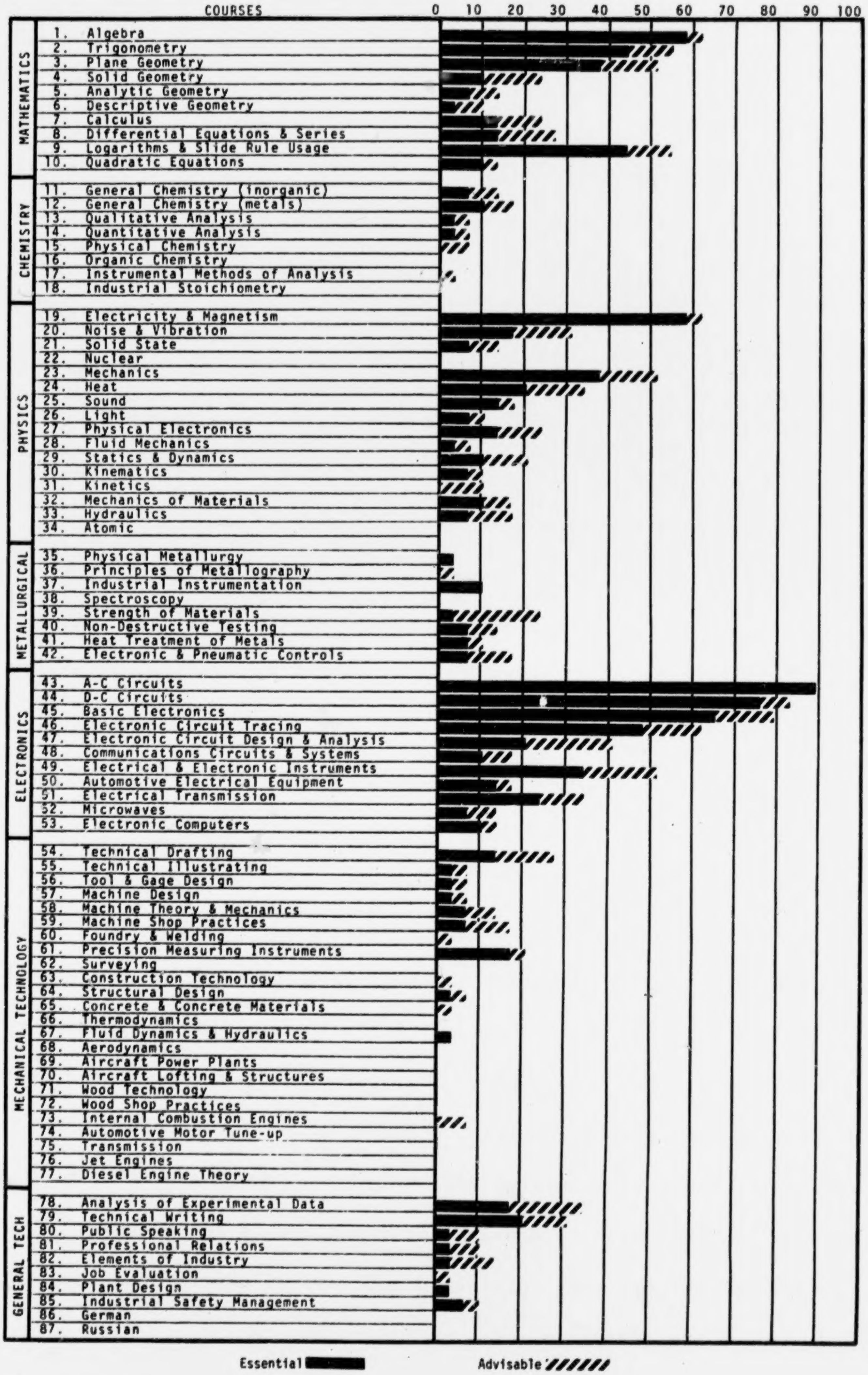
Test Technician (Electric Motors) Some 29 companies expressed their preferences with regard to the curriculum of students trained to be Test Technicians (Electric Motors), Figure 75. They chose a specialized curriculum which required course work in mathematics, physics, and electricity and electronics. The only other area represented in their selections was that of general technology, from which they chose two electives.

The needed mathematics background included algebra, trigonometry, and logarithms and slide rule usage. From the area of physics, instruction in electricity and magnetism was deemed essential. Finally, from the area of electricity and electronics, the respondents chose AC circuits, DC circuits, basic electronics, and electronic circuit tracing as essential courses.

Besides the essential course work given above, the respondents chose several advisable additions from the same general areas of technology. First, from the area of mathematics, they chose plane geometry. From the area of physics, they indicated that instruction in mechanics was advisable. From the general area of electricity and electronics, they showed course work in electronic circuit design and analysis, and electrical and electronic instruments, to be advisable.

The electives chosen for this curriculum were within the areas of physics, electricity and electronics, and general technology. In the area of physics, the respondents felt that training in noise and vibration and heat would be preferred electives. From the area of electricity and electronics,

FIGURE 75: TEST TECHNICIAN (ELECTRIC MOTORS)



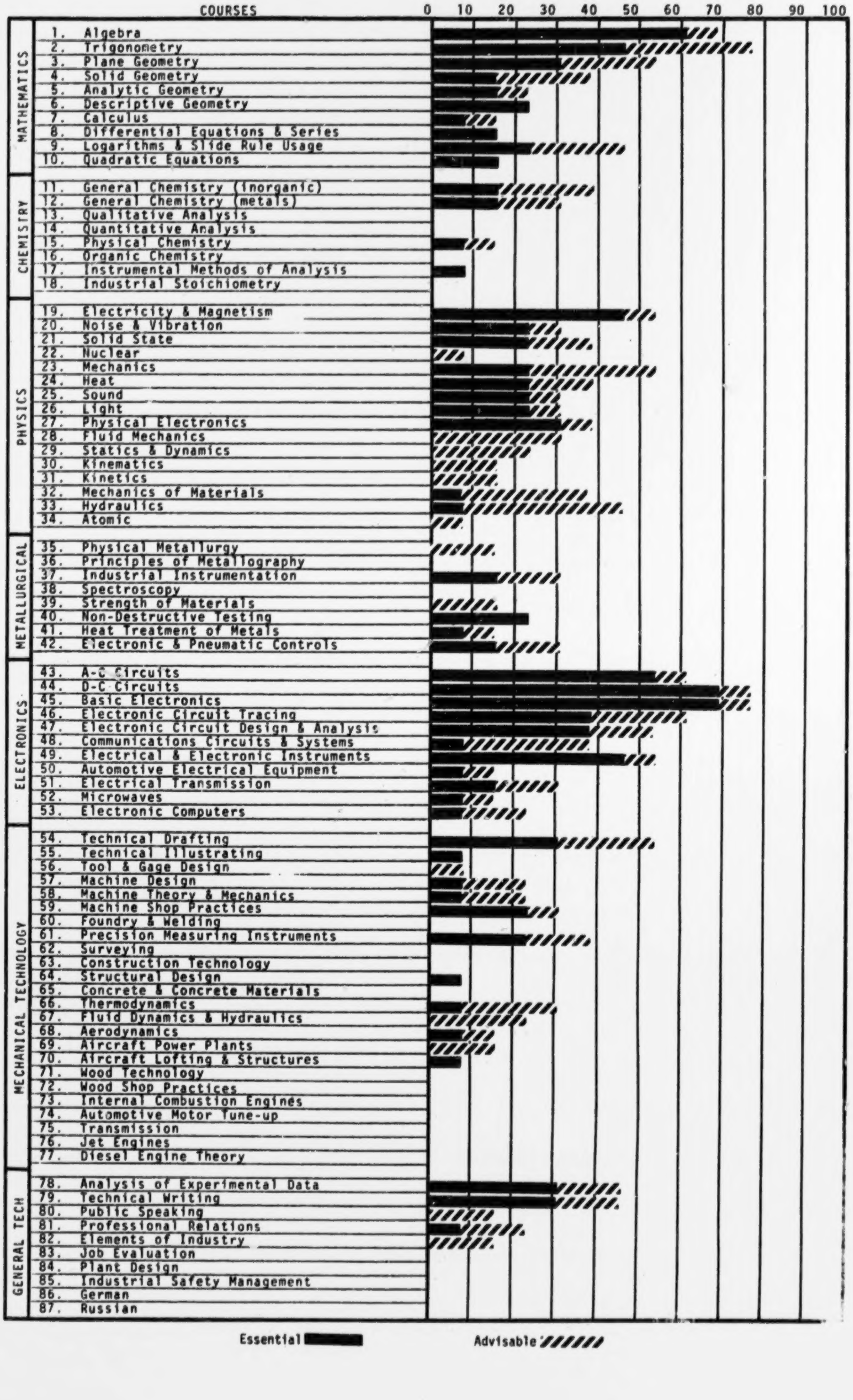
they suggested electrical transmission. Finally, from the area of general technology, they suggested analysis of experimental data and technical writing as preferred electives.

Experimental Technician (Aircraft) A total of 13 companies exercised judgments with reference to the Experimental Technician (Aircraft), Figure 76. Their views indicated with reference to this curriculum that there were only a few essential courses, a large number of advisable courses, and a relatively large number of courses in the elective category. The core of essential courses was selected from the areas of mathematics, physics, and electricity. There were also advisable courses in the areas of mechanics and general technology and elective courses in the area of metals.

The essential mathematics background for the Experimental Technician (Aircraft) consisted of algebra and trigonometry. In the area of physics, instruction in electricity and magnetism was considered essential. The needed course work in the area of electricity and electronics included courses in AC circuits, DC circuits, basic electronics, and electrical and electronic instruments.

The courses which the respondents indicated as advisable were selected once again from the areas of mathematics, physics, and electricity and electronics, but also included courses from the areas of mechanics and general technology. First of all, in the area of mathematics training, it was felt that plane geometry and logarithms and slide rule usage was advisable. Also, this curriculum should include physics instruction in mechanics and hydraulics. The advisable course work selected from the area of electricity and electronics was electronic circuit tracing and electronic circuit design and analysis. From the area of mechanics, the respondents indicated that technical drafting should be taken, and from the area of general technology, they considered analysis of experimental data and technical writing to be advisable.

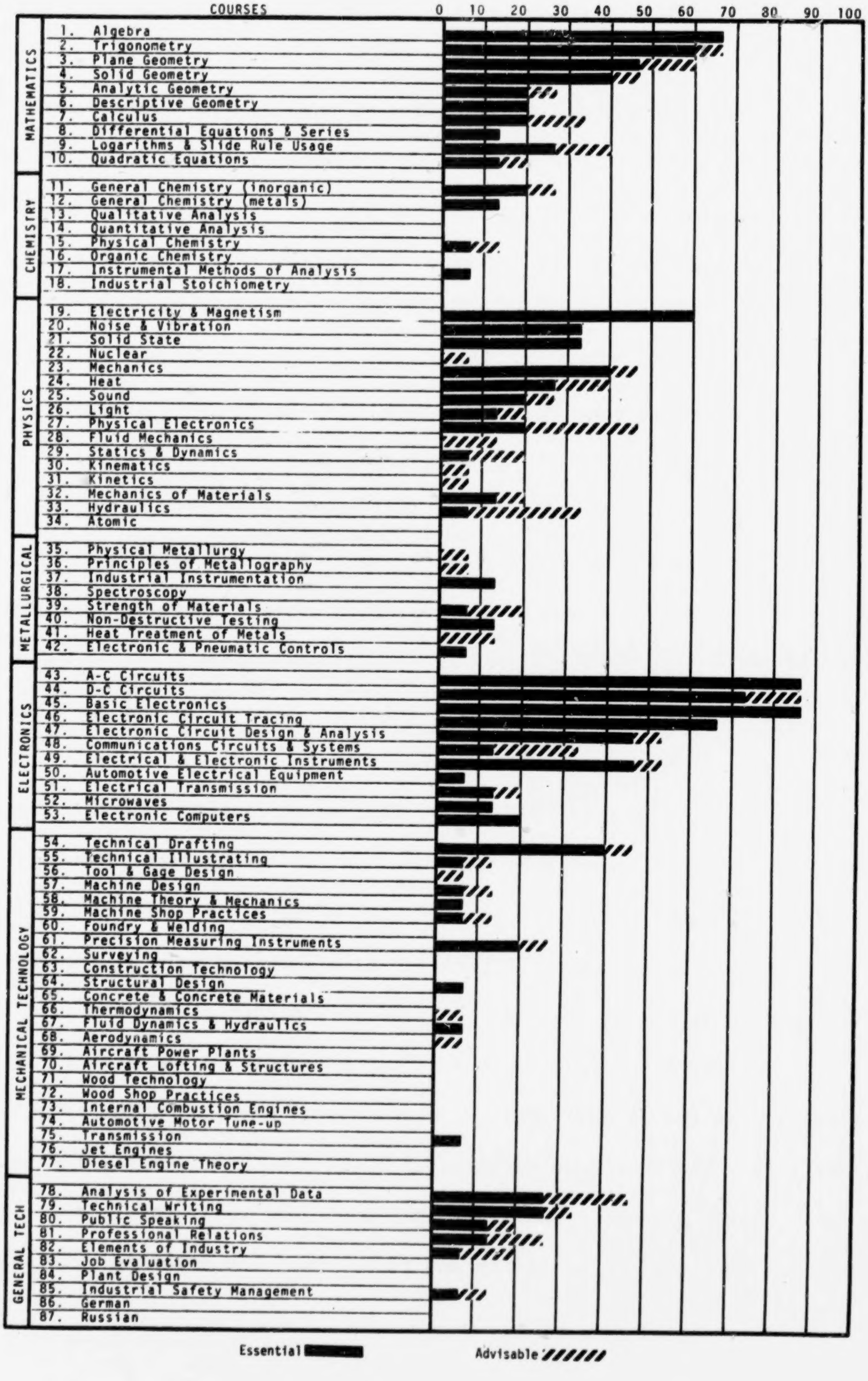
FIGURE 76: EXPERIMENTAL TECHNICIAN (AIRCRAFT)



The list of the electives which the respondents chose for this curriculum was relatively long. It included course work in the areas of mathematics, chemistry, physics, metals, electricity and electronics, and mechanics. The only elective chosen from the area of mathematics was solid geometry. General chemistry (both inorganic and metals) was suggested as an elective. There were a number of preferred electives within the area of physics instruction. These included noise and vibration, solid state, heat, sound, light, physical electronics, fluid mechanics, and mechanics of materials. The elective metals courses were industrial instrumentation, and electronic and pneumatic controls. From the area of electricity and electronics, communications circuits and systems and electrical transmission were suggested electives. Finally, from the area of mechanics, machine shop practices, precision measuring instruments, and thermodynamics were suggested.

Solenoid Technician A total of 15 different companies expressed their desires with regard to the training of the Solenoid Technician, Figure 77. They outlined another relatively specialized curriculum with course work selected from the areas of mathematics, physics, electricity and electronics, mechanics, and general technology. The mathematics background was emphasized along with physics and electronics training. The essential course work selected for the solenoid technician, included courses from the areas of mathematics, physics, electricity and electronics, and mechanics. The required mathematics courses were algebra, trigonometry, plane geometry, and solid geometry. Physics instruction in electricity and magnetism and mechanics was considered essential. There were a number of essential courses in the area of electricity and electronics. These included AC circuits, DC circuits, basic electronics, electronic circuit tracing, electronic circuit design and analysis, and electrical and electronic

FIGURE 77: SOLENOID TECHNICIAN



instruments. In addition to these courses, technical drafting was selected from the area of mechanics as an essential.

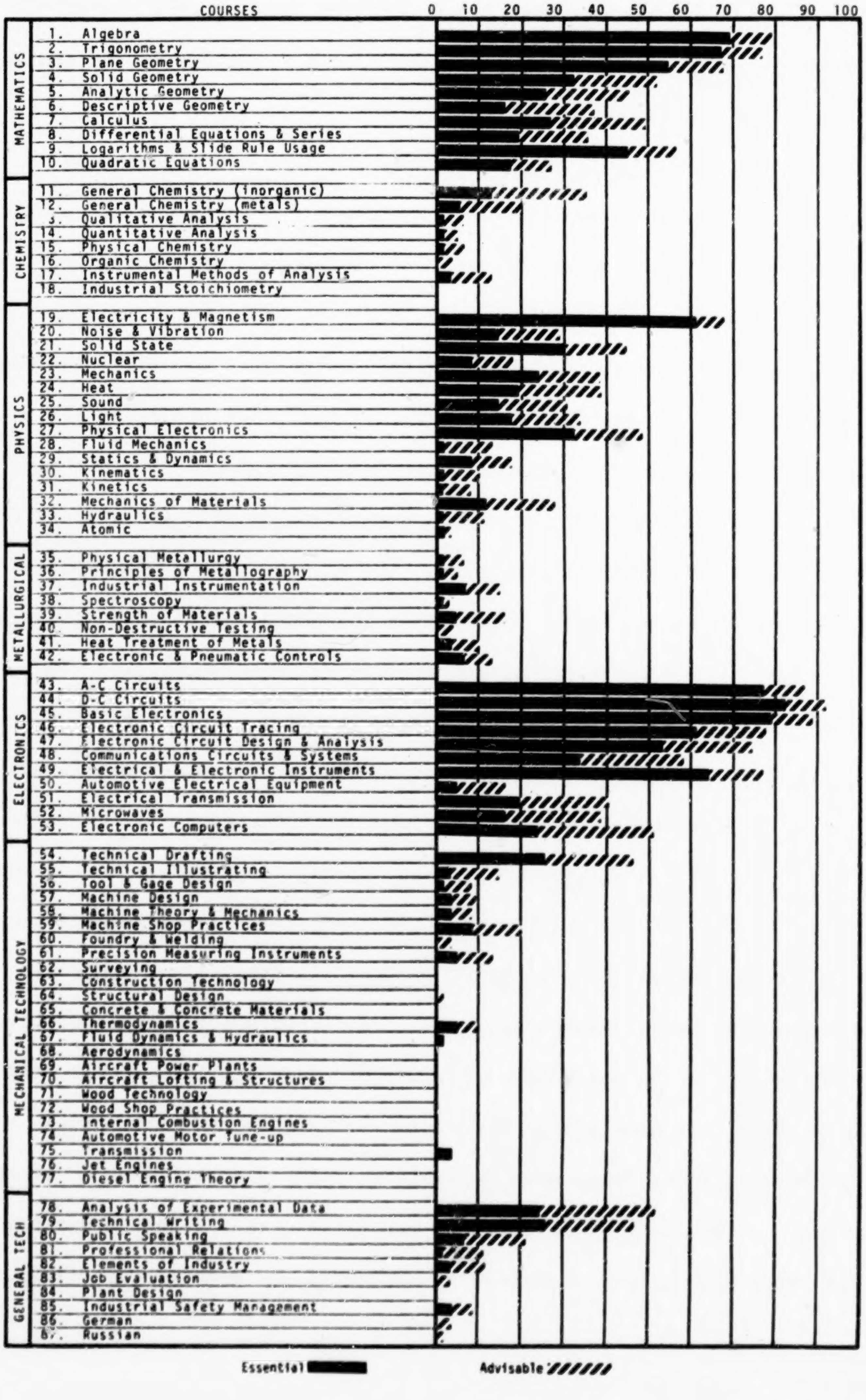
There was a relatively small number of courses which were deemed advisable additions to this curriculum. The respondents felt that logarithms and slide rule usage should be taken from the area of physics. They selected heat and physical electronics as advisable instruction. From the area of general technology, analysis of experimental data was also deemed advisable.

The elctives preferred for this curriculum were courses chosen from the areas of mathematics, physics, electricity and electronics, and general technology. Calculus was the only elective from the area of mathematics. From the area of physics, instruction in noise and vibration, solid state, and hydraulics was suggested. From the area of electricity and electronics, communications circuits and systems was indicated to be a preferred elective, as was technical writing from the area of general technology.

Research Technician, Electronic Systems Some 62 companies reported their curricular preferences with reference to training for the Research Technician, Electronic Systems, Figure 78. The respondents outlined a rigorous and somewhat specialized curriculum which emphasized mathematics training through calculus, some training in physics, and a heavy emphasis on training in the area of electricity and electronics. Also selected were some courses from the areas of mechanics, general technology, and chemistry.

The essential courses for the Research Technician, Electronic Systems were selected from the general areas of mathematics, physics, and electricity and electronics. The necessary mathematics background consists of algebra, trigonometry, plane geometry, and logarithms and slide rule usage. Also needed was physic instruction in electricity and magnetism. The essential electricity

FIGURE 78: RESEARCH TECHNICIAN, ELECTRONIC SYSTEMS



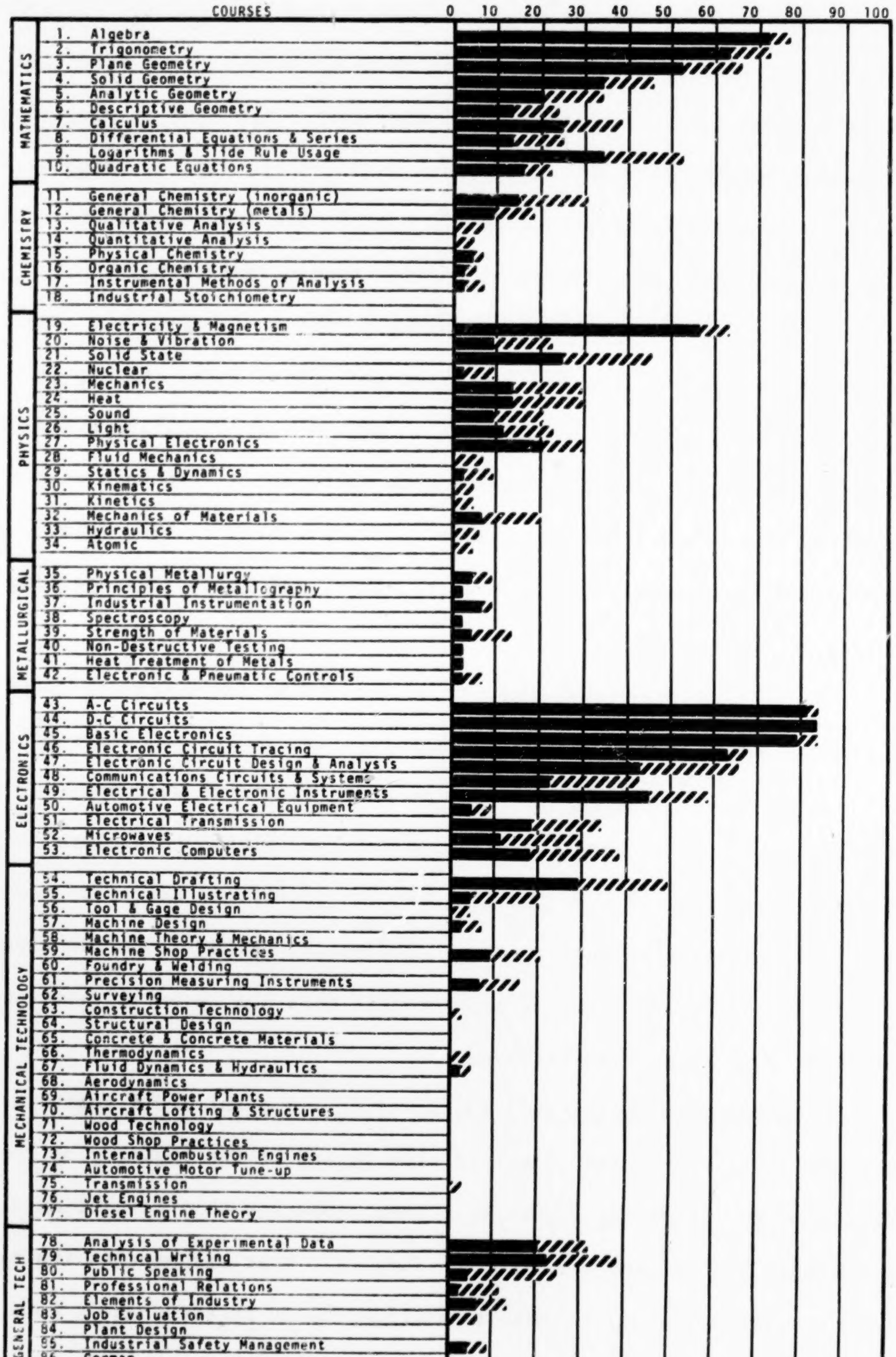
and electronics course work consisted of AC circuits, DC circuits, basic electronics, electronic circuit tracing, electronic circuit design and analysis, plus electrical and electronic instruments.

The courses indicated to be advisable for this curriculum were selections from the areas of mathematics, physics, electricity and electronics, mechanics, and general technology. First from the area of mathematics, it was felt that solid geometry, analytic geometry, and calculus were advisable. Physics instruction in solid state and physical electronics should be included. The advisable electricity and electronics courses were communications circuits and systems, electrical transmission, and electronic computers. From the area of mechanics, technical drafting was deemed advisable, as well as analysis of experimental data and technical writing from the area of general technology.

The elective course work which the respondents suggested as preferrable included selections from the areas of mathematics, chemistry, physics, and electricity and electronics. In the area of mathematics, it was felt that descriptive geometry and differential equations and series would be desirable electives. General chemistry (inorganic) came within the elective classification as did physics instruction in mechanics, heat, sound, and light. Microwaves was selected from the area of electricity and electronics as a preferred elective.

Electronic Technician, Printed Circuits A total of 44 companies exercised judgments with reference to the Electronic Technician, Printed Circuits, Figure 79. The curriculum which they selected was very similar to that outlined for the Electrical Test Development Technician. The areas of mathematics, physics, and electricity and electronics were emphasized, along with a course in technical drafting. None of the other general areas was represented, with the exception of some electives chosen from the areas of chemistry and general technology.

FIGURE 79: ELECTRONIC TECHNICIAN, PRINTED CIRCUITS



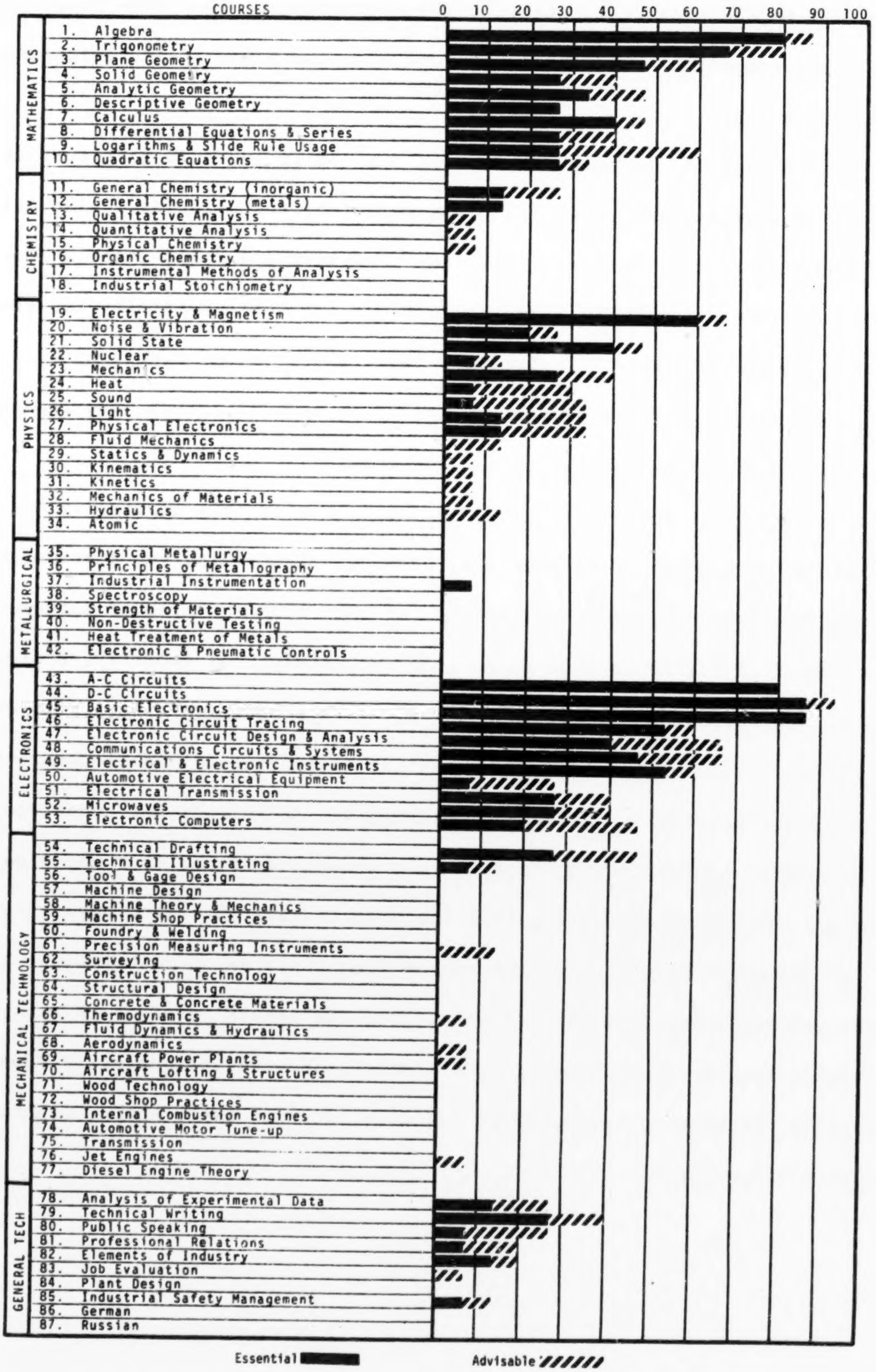
The mathematics training considered essential for the curriculum consisted of algebra, trigonometry, and plane geometry. Also essential was physics instruction in electricity and magnetism. A number of electricity and electronics courses were listed as essentials. These were AC circuits, DC circuits, basic electronics, electronic circuit tracing, electronic circuit design and analysis, and electrical and electronic instruments.

The respondents selected advisable course work from the same general areas of technology as they did the essential course work. First, from the area of mathematics, they felt that solid geometry and logarithms and slide rule usage were advisable. Physics training in solid state also came within this classification. From the area of electricity and electronics, communications circuits and systems was deemed advisable along with technical drafting from the area of mechanics.

The electives preferred by the responding companies were chosen from the general areas of mathematics, chemistry, electricity and electronics, and general technology. The preferred mathematics electives were analytic geometry and calculus. General chemistry (inorganic) came within this classification. The electives suggested from the area of electricity and electronics were electrical transmission and electronic computers. Finally, in the area of general technology, analysis of experimental data and technical writing were indicated to be preferred electives.

Electronic Technician, Multiplexing A total of 15 companies expressed their curricular judgments with regard to the training of the Electronic Technician, Multiplexing, Figure 80. They chose for this occupation a demanding and somewhat specialized curriculum. They felt that mathematics training was needed through calculus, as well as instruction in physics, and a good deal of

FIGURE 80: ELECTRONIC TECHNICIAN, MULTIPLEXING



course work in the area of electricity and electronics. They also found it advisable to suggest two additional courses from the areas of mechanics and general technology.

The mathematics background which must be included in this curriculum consisted of algebra, trigonometry, plane geometry, and calculus. Also essential was physics instruction in electricity and magnetism and solid state. There were a number of essential courses selected from the area of electricity and electronics. These included AC circuits, DC circuits, basic electronics, electronics circuit tracing, electronic circuit design and analysis, communications circuits and systems, and electrical and electronic instruments.

The course work indicated to be advisable in this curriculum was selected from the areas of mathematics, physics, electricity and electronics, mechanics, and general technology. First of all, from the area of mathematics, it was deemed advisable to have solid geometry, analytical geometry, differential equations and series, and logarithms and slide rule usage. Physics instruction in mechanics should be included. The advisable electricity and electronics courses were electrical transmission, microwaves, and electronic computers. Also considered advisable was a course in technical drafting from the area of mechanics, and technical writing from the area of general technology.

With the exception of one course from the area of mathematics, all of the preferred electives were selected from the general area of physics. The mathematics instruction considered a preferred elective was quadratic equations. The physics instruction suggested as elective included heat, sound, light, and physical electronics.

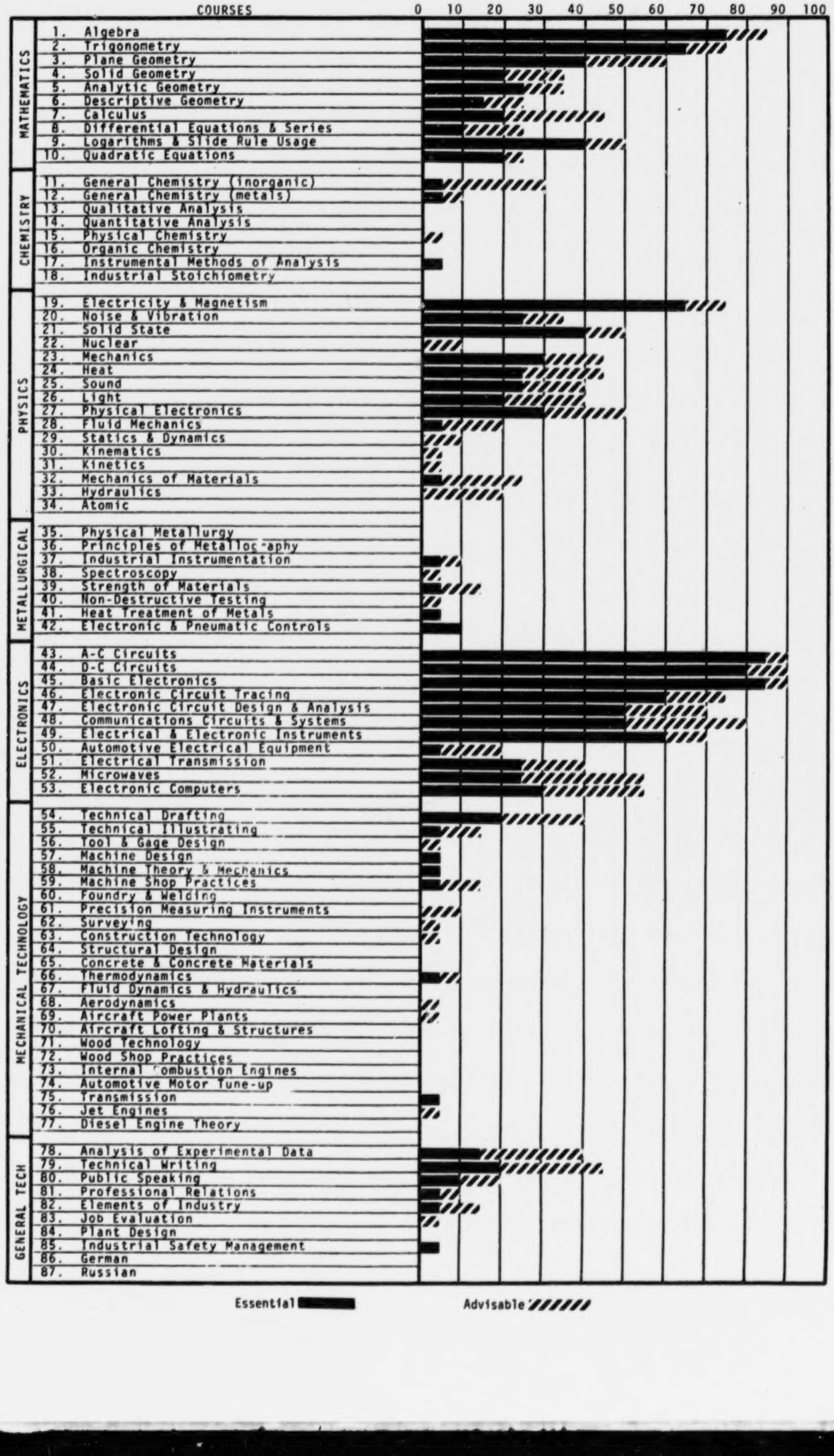
Electronic Technician, Telemetering A total of 20 companies made judgments with reference to the curricular needs of the Electronic Technician, Telemetering, Figure 81. They recommended a curriculum requiring some mathematics and physics background, but placed heavy emphasis upon training in the area of electricity and electronics. Additional courses selected from the areas of mechanics, general technology, and chemistry were considered to be of less importance.

The essential mathematics background for this occupation consisted of algebra, trigonometry, plane geometry, and logarithms and slide rule usage. Physics instruction in electricity and magnetism and solid state was also deemed essential. There were a relatively large number of courses needed in the area of electricity and electronics. These courses were AC circuits, DC circuits, basic electronics, electronics circuit tracing, electronic circuit design and analysis, communications circuits and systems, electrical and electronic instruments.

In addition to these essential courses, the respondents felt that course work in mathematics, physics, electricity, mechanics, and general technology would be advisable. Specifically, they felt that calculus was an advisable course from the area of mathematics. Physics instruction in mechanics, heat, sound, light, and physical electronics came within the advisable classification as did electricity and electronics instruction in electrical transmission, microwaves, and electronic computers. From the area of mechanics, technical drafting was chosen as an advisable course. It was also felt that analysis of experimental data and technical writing should be included in this curriculum from the area of general technology.

Only a few courses were selected as preferred electives. These were chosen from the areas of mathematics, chemistry, and physics. First, from the

FIGURE 81: ELECTRONIC TECHNICIAN, TELEMETERING



area of mathematics, solid geometry and analytic geometry were suggested. General chemistry (inorganic) was also chosen as a preferred elective, as was physics instruction in noise and vibration.

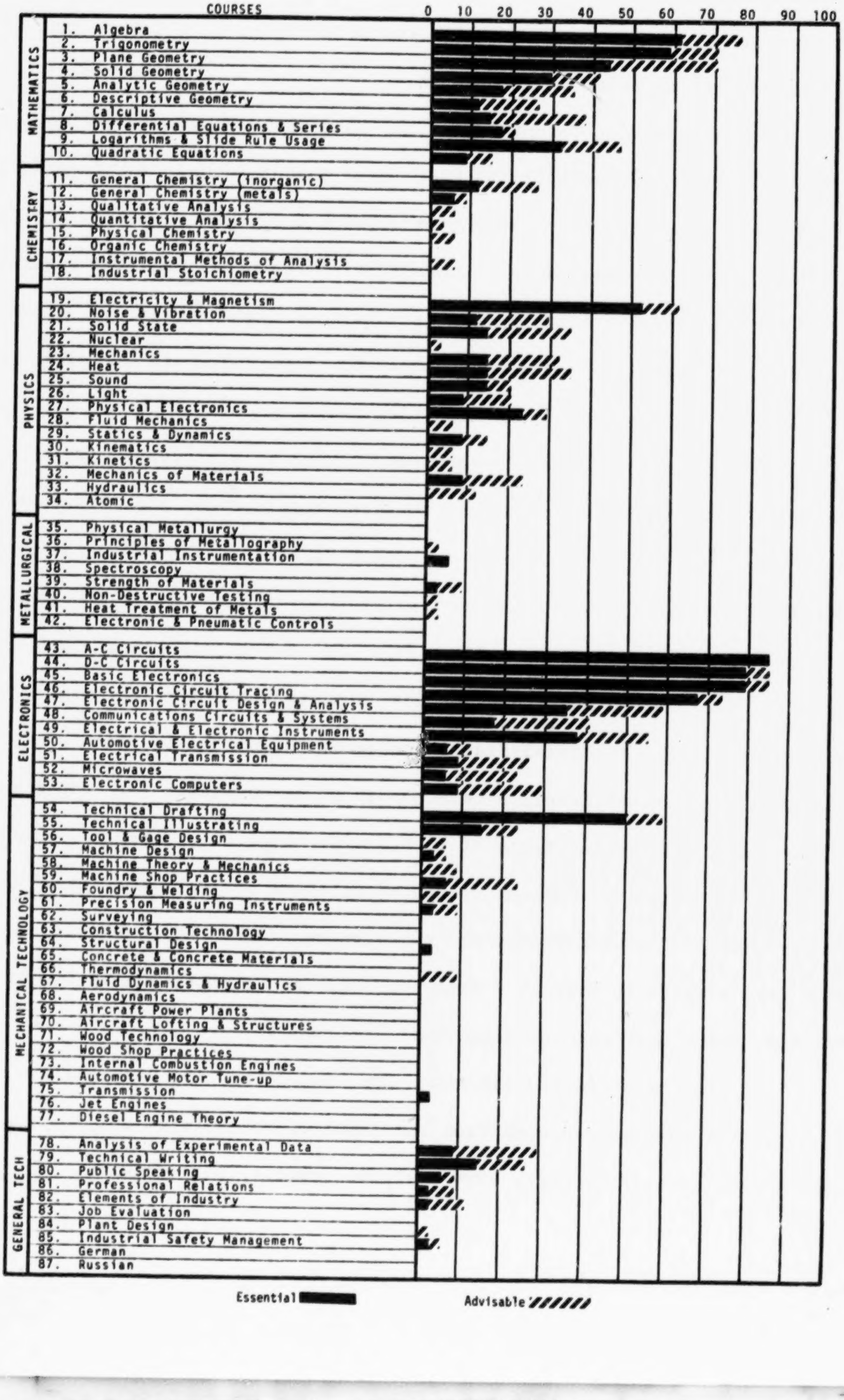
Electronic Layout Technician. Some 34 companies made judgments with regard to the curricular needs of the Electronic Layout Technician, Figure 82. A similarity was noted between the program outline for this occupation and that of the Electrical Design Draftsman. Compared with the other programs outlined in the area of electrical technology, this course of study would be relatively simple, requiring a limited amount of course work from the areas of mathematics, physics, and electricity and electronics plus technical drafting.

The courses considered to be essential for this occupation were selected from the areas of mathematics, physics, electronics, and mechanics. The mathematics background considered necessary consisted of courses in algebra, trigonometry, and plane geometry. Physics training in electricity and magnetism was also needed, along with four courses from the area of electricity and electronics: AC circuits, DC circuits, basic electronics, and electronic circuit tracing. Also deemed necessary was a technical drafting course chosen from the area of mechanics.

A few additional courses were chosen to be advisable for this curriculum, which were selected from the areas of mathematics and electricity and electronics. The advisable mathematics training consisted of solid geometry and logarithms and slide rule usage. The electricity and electronics courses which should be included were electronic circuit design and analysis, communications circuits and systems, and electrical and electronic instruments.

The list of preferred electives for this curriculum was relatively small, including only course work from the areas of mathematics and physics. The elective mathematics courses were analytic geometry and calculus. The

FIGURE 82: ELECTRONIC LAYOUT TECHNICIAN



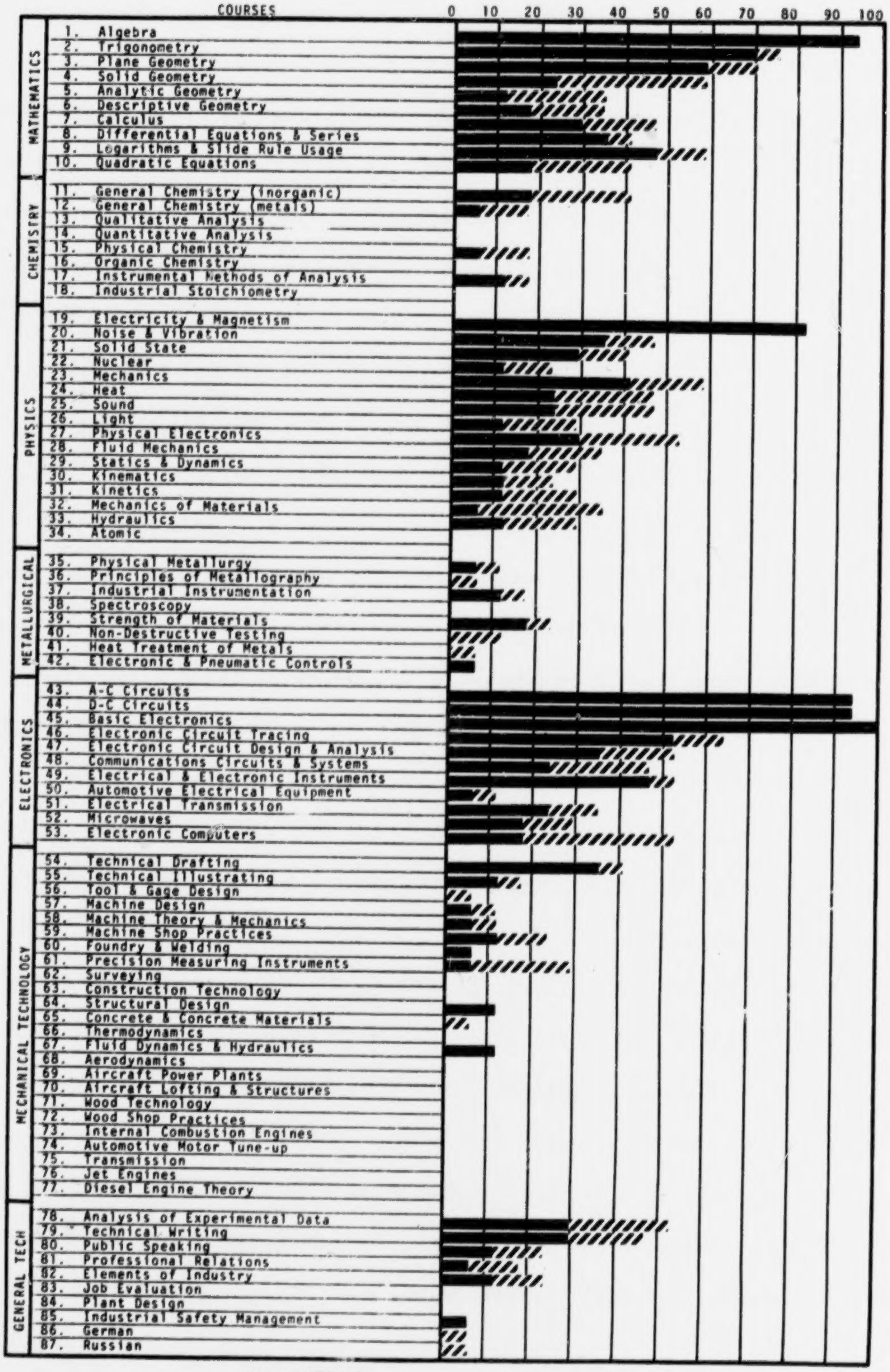
physics instruction chosen as preferred electives consisted of solid state, mechanics, and heat.

Transducer Development Technician Curricular recommendations were made by 17 companies for those preparing to work as Transducer Development Technician in industry, Figure 83. The companies' judgments made this one of the more rigorous and diversified curricula among those outlined in the area of electrical technology. The general areas of mathematics, chemistry, physics, electricity and electronics, mechanics, and general technology were all represented among their course selections, and it is noted that advanced mathematics courses are desired, as well as some concentration within the area of electricity and electronics.

The essentials for the Transducer Development Technician were courses selected from the areas of mathematics, physics, and electricity and electronics. In the area of mathematics, this consisted of algebra, trigonometry, plane geometry, and logarithms and slide rule usage. In the area of physics instruction, they chose electricity and magnetism, and mechanics as essentials. The essential course work selected from the area of electricity and electronics was AC circuits, DC circuits, basic electronics, electronic circuit tracing, and electrical and electronic instruments.

Added to this list of basic essentials for this curriculum, the respondents indicated a relatively long list of advisable course work, selecting courses from the areas of mathematics, chemistry, physics, electricity and electronics, mechanics, and general technology. First, from the area of mathematics, they felt that this curriculum should include solid geometry, calculus, differential equations and series, and quadratic equations. General chemistry (inorganic) was also desired, along with physics instruction in noise

FIGURE 83: TRANSDUCER DEVELOPMENT TECHNICIAN



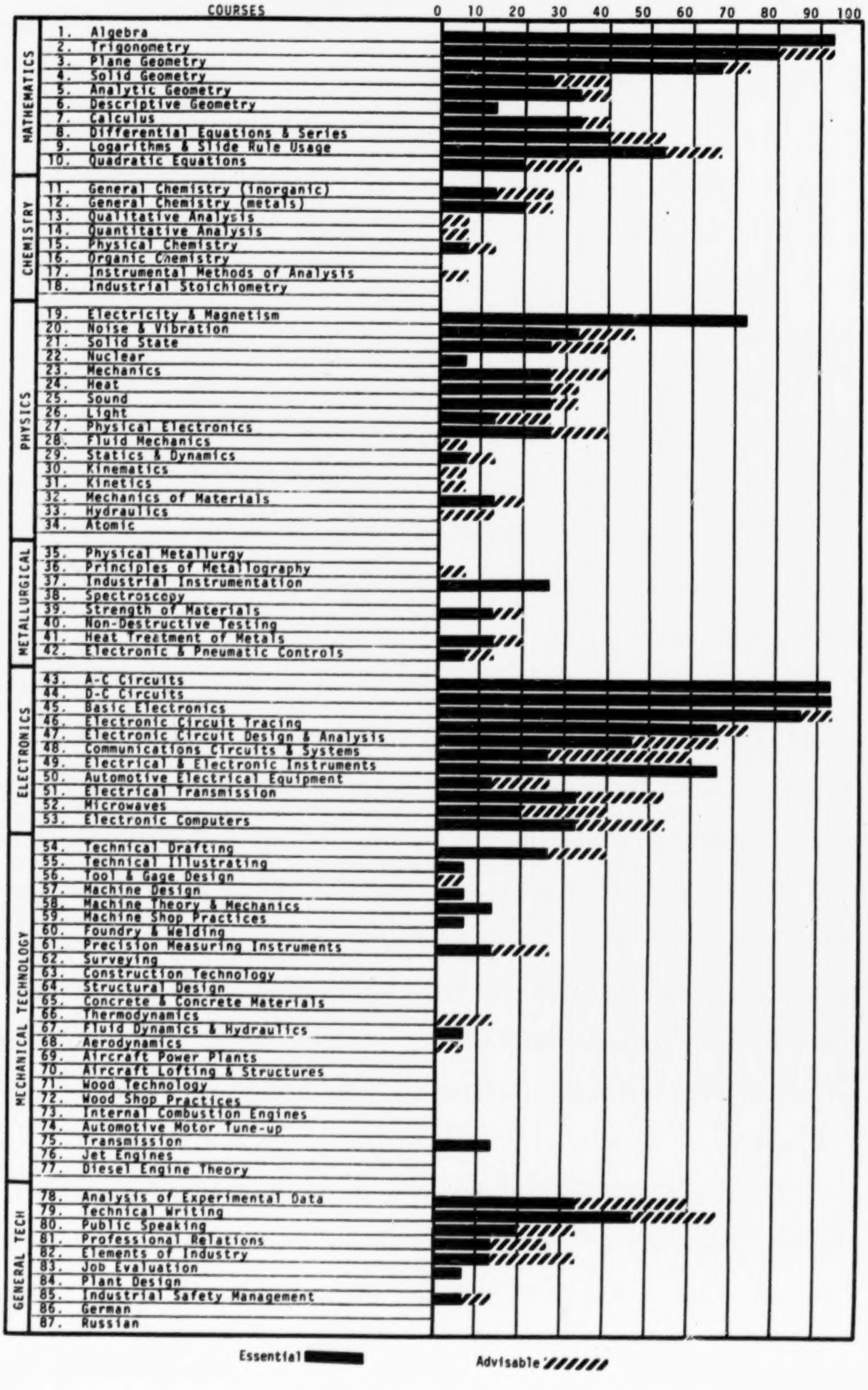
and vibration, solid state, heat, sound, and physical electronics. The additional instruction in the area of electricity and electronics considered to be advisable consisted of electronic circuit design and analysis, communications circuits and systems, and electronic computers. In the area of mechanics, technical drafting was considered to be advisable. And finally, from the area of general technology, analysis of experimental data and technical writing came with the advisable classification.

Of the remaining electives, the respondents preferred additional training from the area of mathematics, physics, and electricity and electronics. In the area of mathematics they selected analytic geometry and descriptive geometry. Physics instruction in fluid mechanics and mechanics of materials was a preferred elective, as was electrical transmission from the area of electricity and electronics.

Test Technician, Guidance Systems A total of 15 companies expressed their desires with regard to the training of the Test Technician, Guidance Systems, Figure 84. The course of study which they selected for this occupation was one of the more rigorous and diversified among the electricity and the electronics curricula. The desired course work was selected from the areas of mathematics, physics, electricity and electronics, mechanics, and general technology. In general, this curriculum consisted of a strong mathematics background, some background in physics, a relatively strong concentration in the area of electricity and electronics, plus technical drafting and some selections from the area of general technology.

The essential mathematics training included algebra, trigonometry, plane geometry, differential equations and series, and logarithms and slide rule usage. Physics instruction in electricity and magnetism was needed. The necessary

FIGURE 84: TEST TECHNICIAN, GUIDANCE SYSTEMS



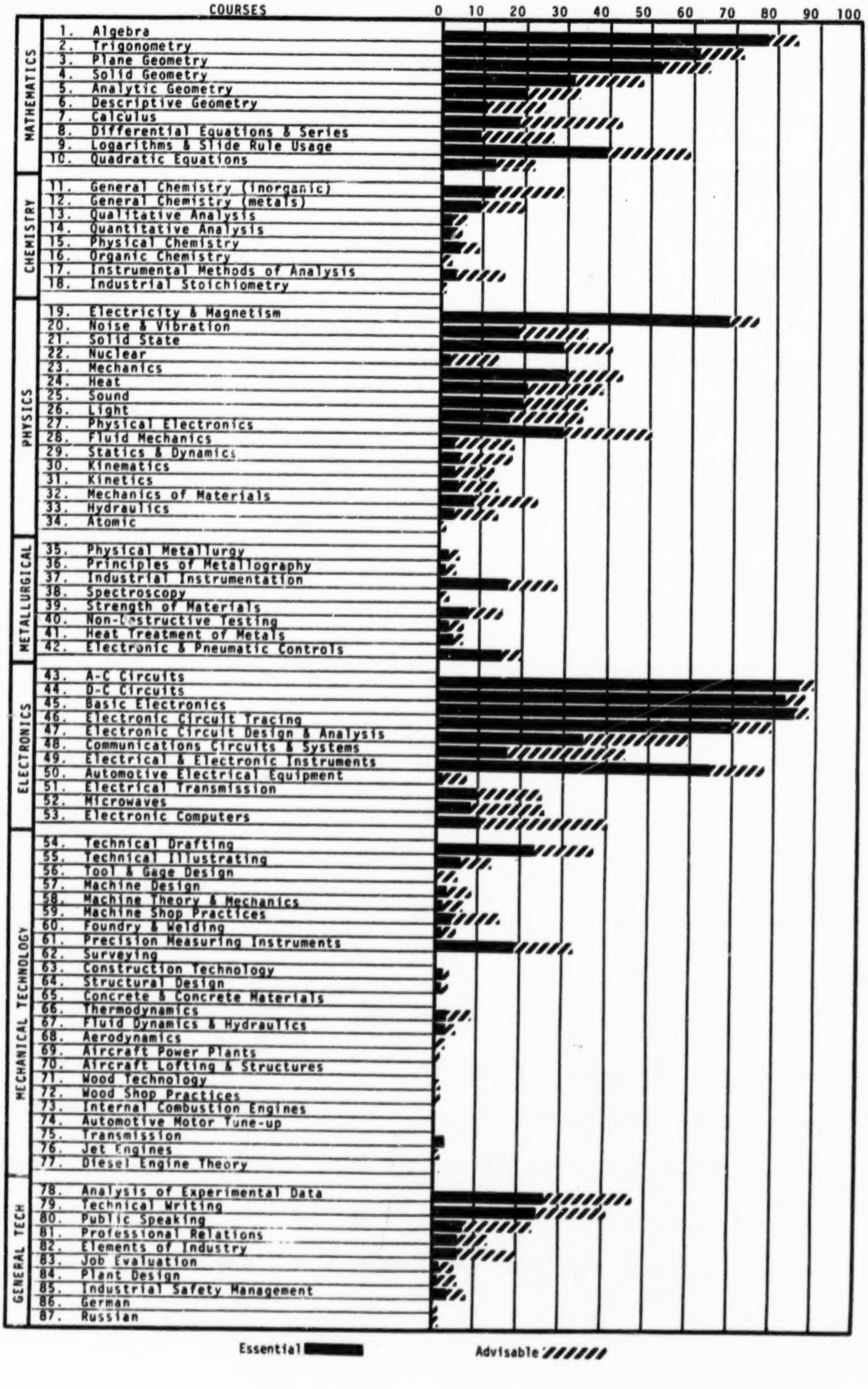
electricity and the electronics course work consisted of AC circuits, DC circuits, basic electronics, electronic circuit tracing, electronic circuit design and analysis, and electrical and electronic instruments. In addition, from the area of general technology, the respondents felt that technical writing was a necessity.

The additional instruction considered by the respondents to be advisable was courses selected from the areas of mathematics, physics, electricity and electronics, mechanics, and general technology. The advisable mathematics courses were solid geometry, analytic geometry, and calculus. Physics instruction in noise and vibration, solid state, mechanics, and physical electronics should be included. The additional electricity and electronics courses considered to be advisable were communications circuits and systems, electrical transmission, microwaves, and electronic computers. Also, from the area of mechanics, technical drafting was indicated as an advisable addition, as well as analysis of experimental data from the area of general technology.

A few electives from the areas of mathematics, physics, and general technology, were preferred by the respondents. From the area of mathematics they suggested quadratic equations as an elective. Physics instruction in heat and sound was suggested, along with general technology courses in public speaking and elements of industry.

Instrumentation Technician, Electronic A total of 86 companies expressed their preferences with regard to the curriculum of the Instrumentation Technician, Electronic, Figure 85. The curriculum chosen was very similar to that already outlined for the Electrical Test Development Technician. The general training emphasis was in the areas of mathematics, physics, and electricity and electronics with additional selections made from mechanics and general technology.

FIGURE 85: INSTRUMENTATION TECHNICIAN, ELECTRONIC



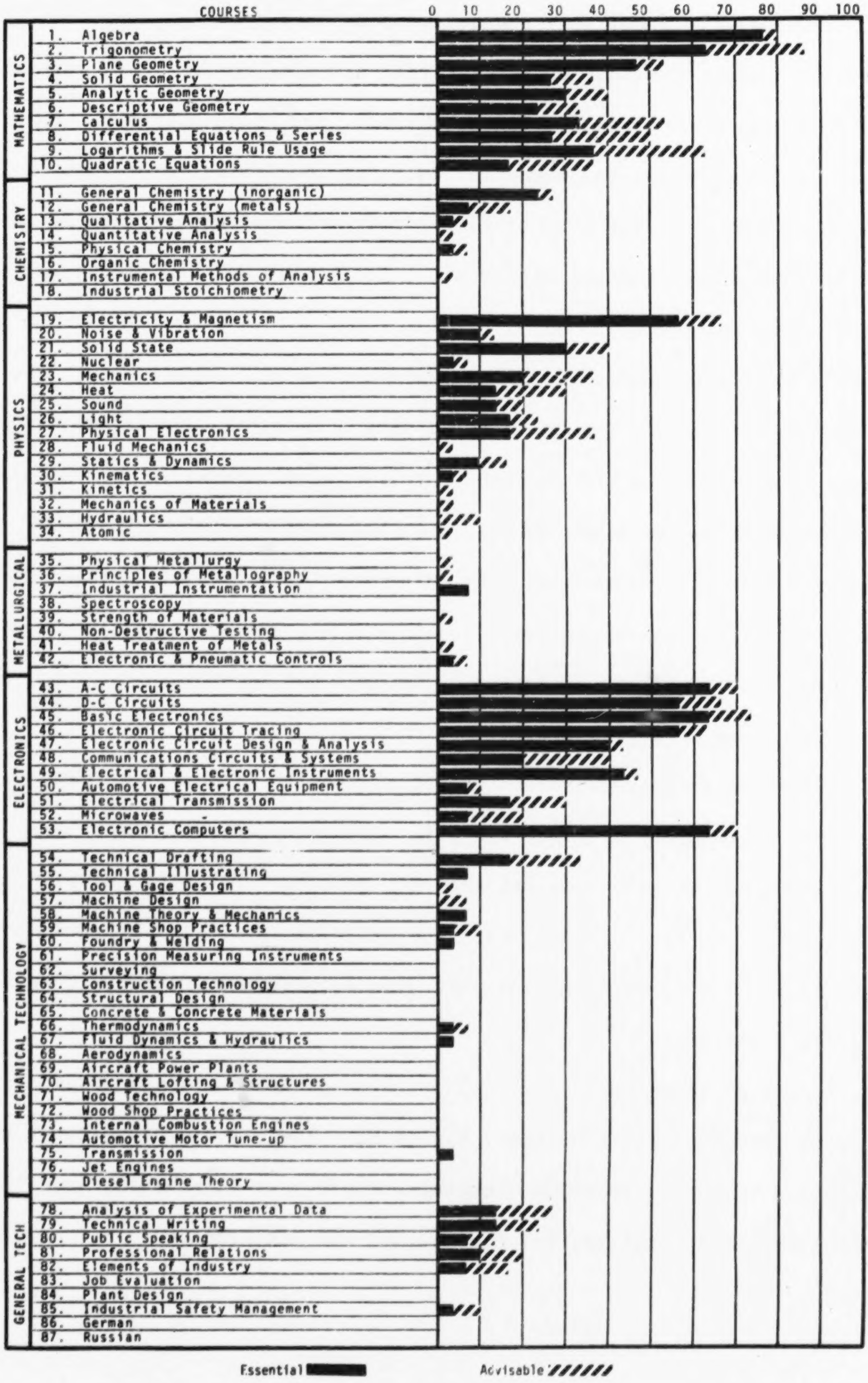
The essentials for this occupation consisted of selections from the areas of mathematics, physics, and electricity and electronics. The essential mathematics background was algebra, trigonometry, and plane geometry. Physics instruction in electricity and magnetism was also considered to be essential. The selections made from the area of electricity and electronics were AC circuits, DC circuits, basic electronics, electronic circuit tracing, and electrical and electronic instruments.

It was considered advisable to have additional course work in the area of mathematics consisting of solid geometry, calculus, and logarithms and slide rule usage. Physics instruction in solid state, mechanics, and physical electronics was also deemed advisable. From the area of electricity and electronics, it was felt that this curriculum should include electronic circuit design and analysis, communications circuits and systems, and electronic computers. Also advisable were analysis of experimental data and technical writing, chosen from the area of general technology.

There were several courses from the areas of mathematics, physics, and mechanics which came under the classification of preferred electives. First, the single mathematics selection was analytic geometry. Physics instruction in noise and vibration, heat, sound, and light was selected. Finally, from the area of mechanics, technical drafting and precision measuring instruments were selected as preferred electives.

Computer Technician A total of 30 companies exercised judgments with reference to the Computer Technician, Figure 86. Their judgments made this a relatively specialized curriculum, concentrating almost exclusively upon the areas of mathematics, physics, and electricity and electronics.

FIGURE 86: COMPUTER TECHNICIAN



The essential mathematics background for the computer technician was algebra, trigonometry, and plane geometry. Physics instruction in electricity and magnetism was also considered to be essential. The needed course work in electricity and electronics consisted of AC circuits, DC circuits, basic electronics, electronic circuit tracing, electronic circuit design and analysis, electrical and electronic computers.

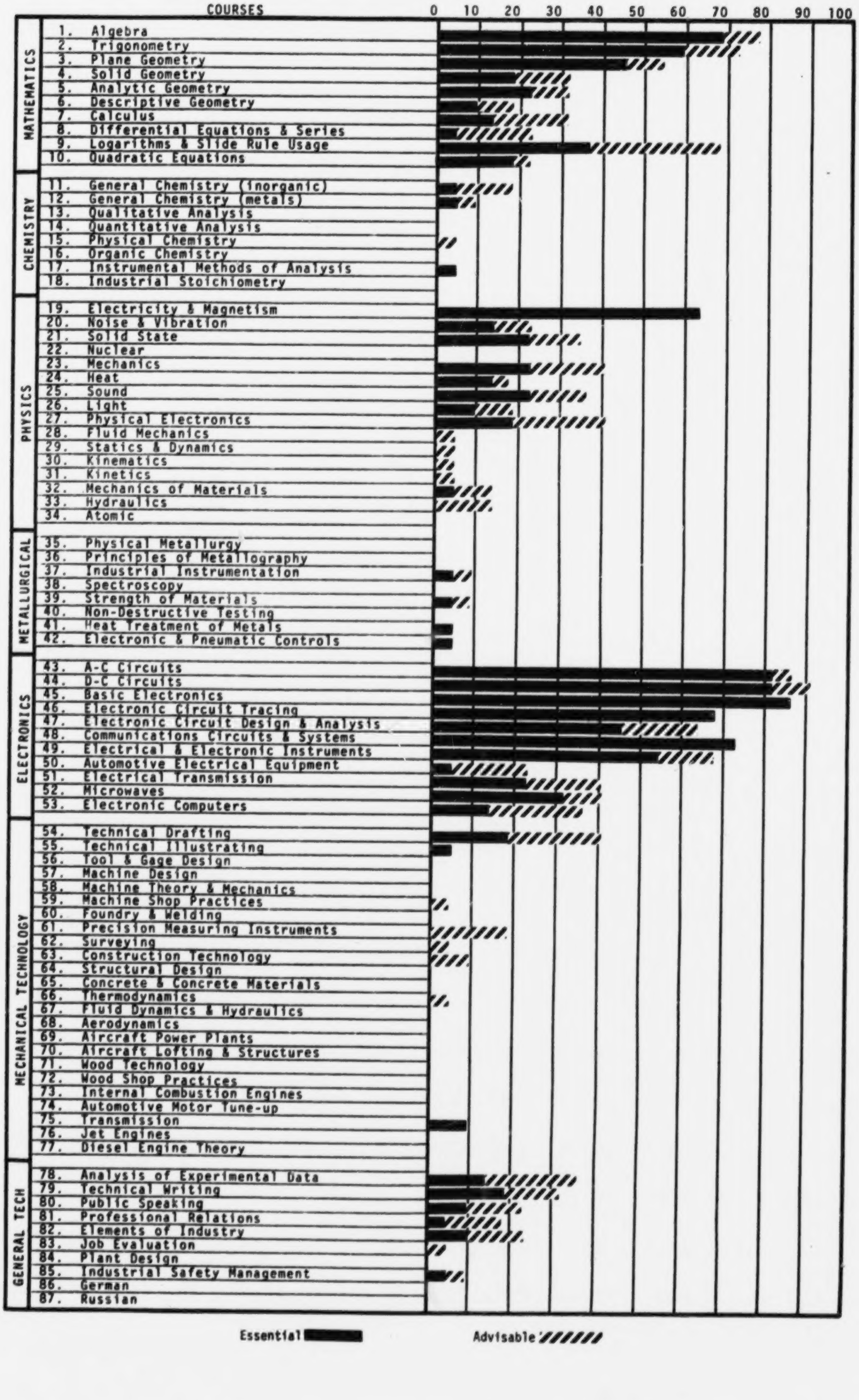
The additional mathematics background considered to be advisable by the responding companies consisted of analytic geometry, calculus, differential equations and series, and logarithms and slide rule usage. Physics instruction in solid state was also considered an advisable addition, as was communications circuits and systems from the area of electricity and electronics.

The electives preferred by the respondents were selections taken from the areas of mathematics, physics, electricity and electronics, and mechanics. The selections from the area of mathematics were solid geometry, descriptive geometry, and quadratic equations. Physics instruction in mechanics, heat, and physical electronics was preferred. In the area of electricity and electronics, electrical transmission was selected, as was technical drafting from the area of mechanics.

Communications Technician Curricular recommendations were made by some 22 different companies for the preparation of Communications Technician, Figure 87. The curriculum identified by these companies consisted of a basic mathematics and physics background, along with a strong concentration of study in the area of electricity and electronics. A few additional selections were made from the areas of mechanics and general technology. Thus, this also is a relatively specialized program of study.

The essential mathematics background for the Communications Technician consisted of algebra, trigonometry, and plane geometry. The essential physics

FIGURE 87: COMMUNICIATIONS TECHNICIAN



background was instruction in electricity and magnetism. The needed course work in electricity and electronics was AC circuits, DC circuits, basic electronics, electronic circuit tracing, electronic circuit design and analysis, communications circuits and systems, and electrical and electronic instruments.

Some additional courses considered by the respondents to be advisable were selections from the areas of mathematics, physics, electricity and electronics, and mechanics. From the area of mathematics, they selected logarithms and slide rule usage. Physics instruction in mechanics and physical electronics was also deemed advisable. From the area of electricity and electronics the respondents felt that electrical transmission and microwaves should be included along with technical drafting from the area of mechanics.

Other course selections were chosen as preferred electives. From the general area of mathematics, were included solid geometry, analytic geometry, and calculus. From the area of physics instruction, it included solid state and sound. Electronic computers was selected from the area of electricity and electronics, and also suggested were analysis of experimental data and technical writing from the area of general technology.

Sound Technician A total of eight companies responded with regard to the Sound Technician. They indicated that it was necessary for one in this occupation to have a basic background in mathematics, some instruction in chemistry and a few courses in electronics. The electricity and electronics course work would include AC circuits, DC circuits, basic electronics, electronics circuit tracing, and electronic circuit design and analysis. While these are the basic essentials outlined, it was desirable to include some further course work in mathematics, up through analytic geometry and descriptive geometry, some additional work in the area of electronics, and courses in technical drafting, analysis of experimental data, and technical writing.

(Mechanical Technology)

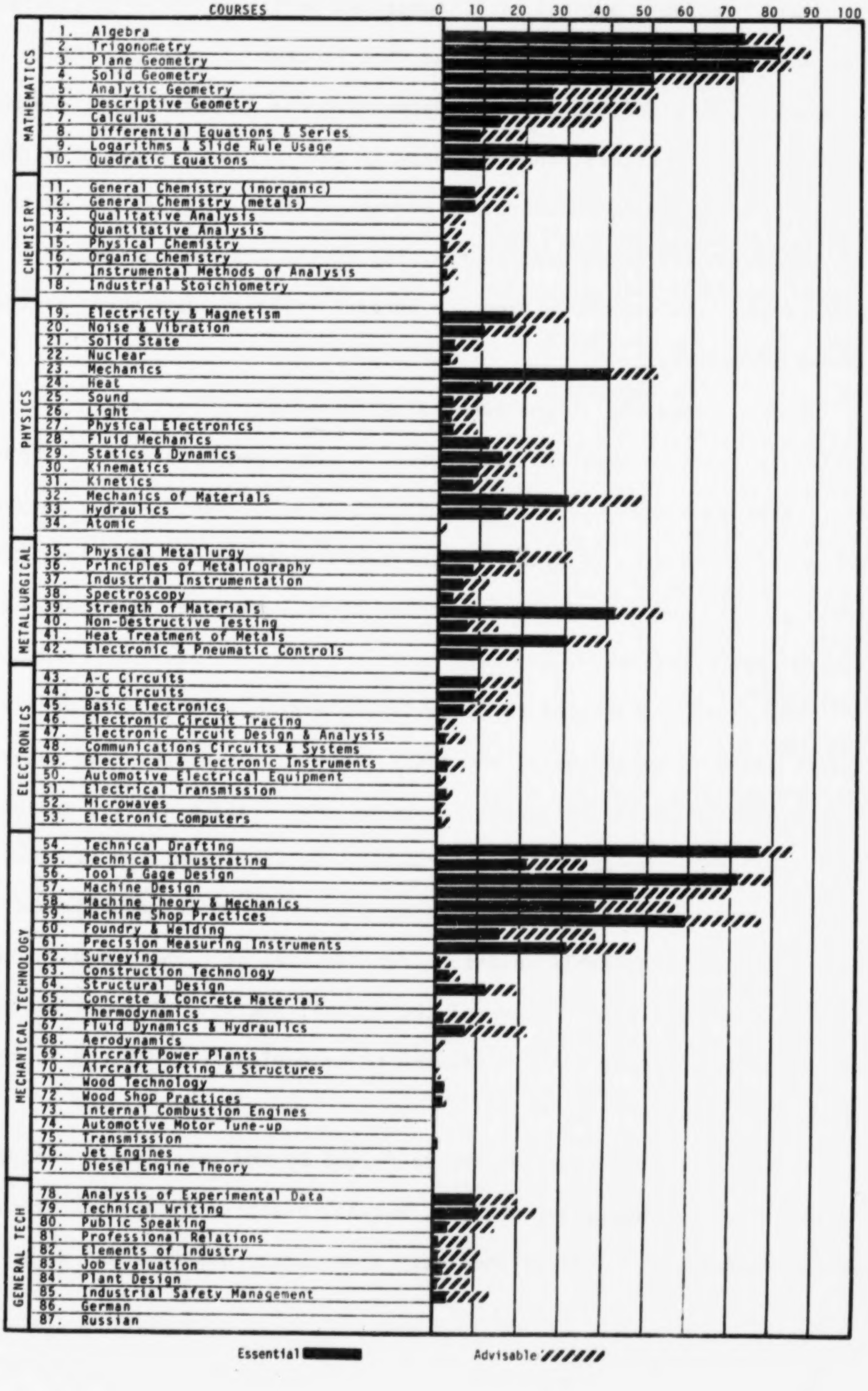
Tool Designer A total of 187 companies exercised judgments with reference to the Tool Designer, Figure 88. Their views indicated with reference to mechanical technology in industry that the Tool Designer curriculum was one of the more rigorous curricula.

The responses indicated that it was essential to have course work in the selected areas of mathematics, physics, metals, and mechanics. The advisable and elective course work was also selected from these same general areas of technology. First, the essential mathematics courses included algebra, trigonometry, plane geometry, and solid geometry. Physics instruction in mechanics was considered to be essential, as well as metals instruction in strength of materials. The needed mechanics course work was technical drafting, tool and gauge design, machine design, and machine shop practices.

The additional mathematics courses considered by the respondents to be advisable for this curriculum were courses in analytic geometry, descriptive geometry, and logarithms and slide rule usage. The responses indicated that physics instruction in mechanics of materials was advisable, as well as metals instruction in heat treatment of metals. The advisable additions in the area of mechanics were machine theory and mechanics, and precision measuring instruments.

Several courses from these same areas were selected as preferred electives by the respondents. Calculus was chosen from the area of mathematics, along with electricity and magnetism from the area of physics instruction. In the area of metals, physical metallurgy was suggested. Finally, the mechanics courses which came within this elective category were technical illustrating and foundry and welding.

FIGURE 88: TOOL DESIGNER



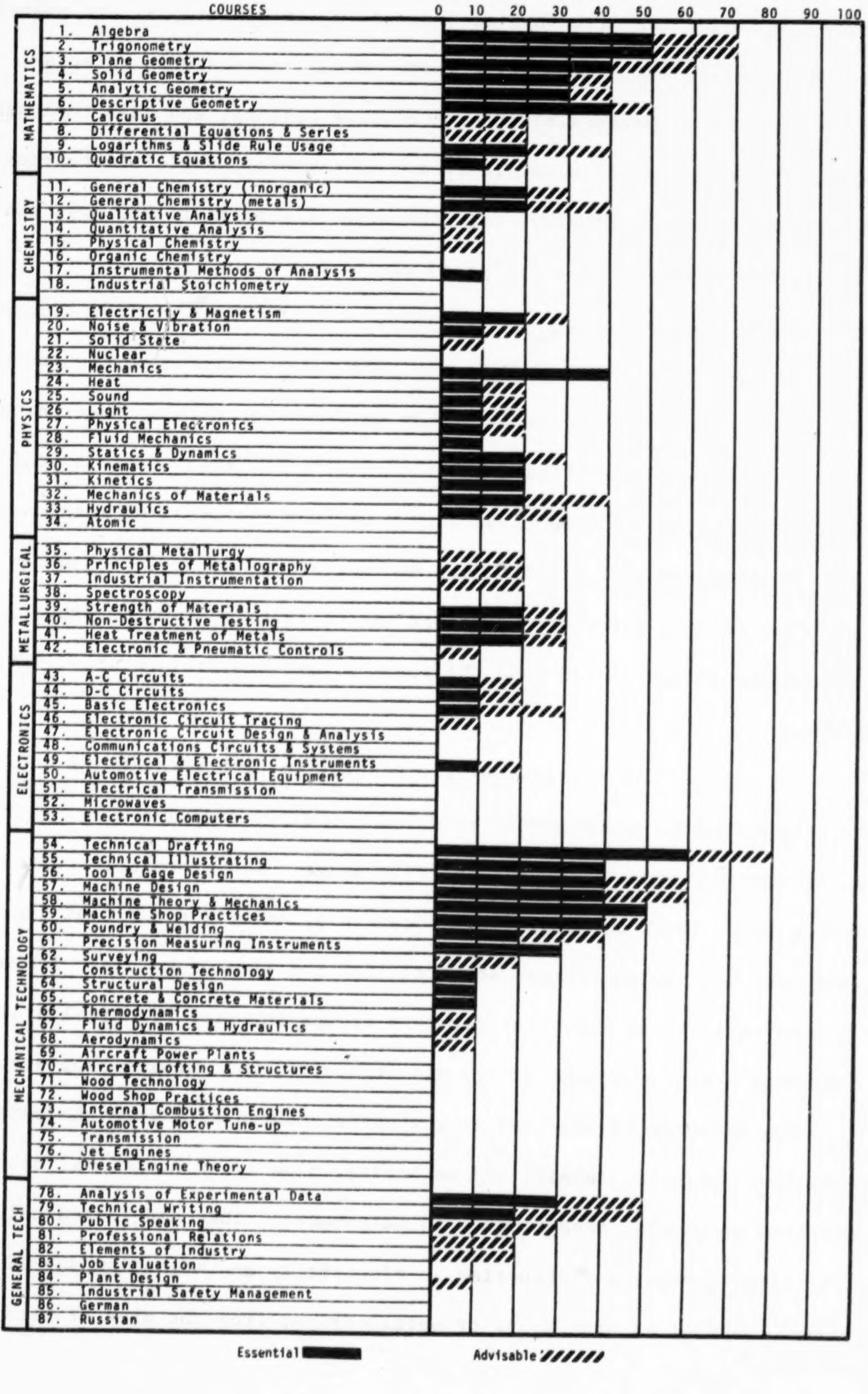
Tool Proofer A total of 10 companies indicated their curricular judgments with regard to training for the Tool Proofer, Figure 89. While the curriculum which they defined for this occupation was in many respects similar to that of the Tool Designer, this appeared to be a broader course of study concentrating, once again, on the areas of mathematics, physics, and mechanics. However, less emphasis was placed on training in the area of metals and additional selections were made from the general areas of chemistry, electricity, and general technology.

In the judgments of the responding companies, it was essential to have mathematics training in algebra, trigonometry, plane geometry, and descriptive geometry. Also essential was physics instruction in mechanics. The necessary course work from the area of mechanics consisted of technical drafting, technical illustrating, tool and gauge design, machine desing, machine theory and mechanics, and machine shop practices.

The courses indicated to be advisable for this curriculum were within the general areas of mathematics, chemistry, physics, mechanics, and general technology. The advisable mathematics courses were solid geometry, analytic geometry, and logarithms and slide rule usage. General chemistry (metals) was considered to be advisable along with physics instruction in mechanics of materials. The only advisable addition from the area of mechanics was foundry and welding. From the area of general technology, analysis of experimental data and technical writing were considered to be advisable additions to this curriculum.

The list of elective courses preferred by the respondents represented the general areas of chemistry, physics, metals, electricity and electronics, and general technology. General chemistry (inorganic) was selected as a

FIGURE 89: TOOL PROOFER



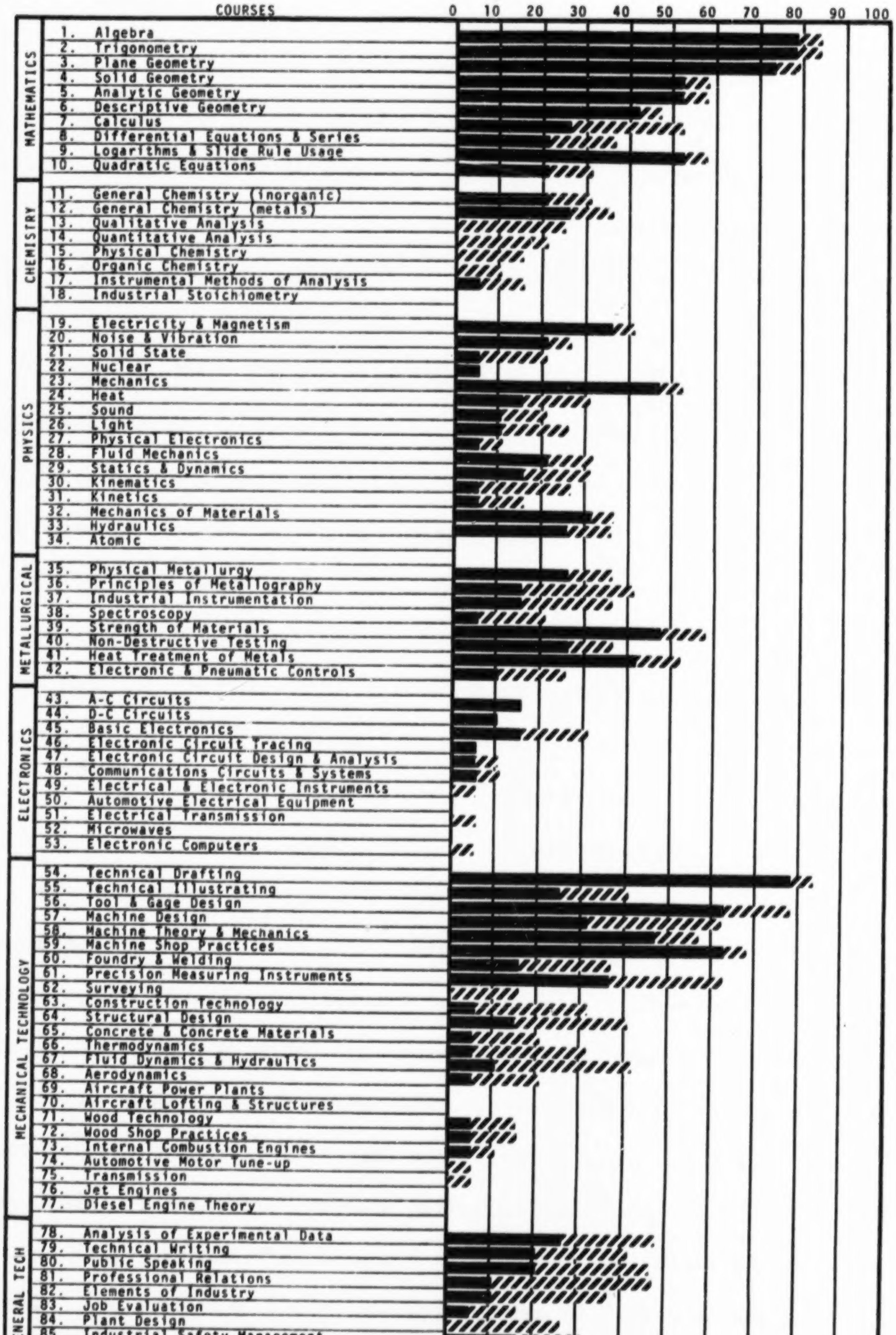
preferred elective, along with physics instruction in electricity and magnetism, statics and dynamics, and hydraulics. Three metals courses were selected. These were strength of materials, non-destructive testing, and heat treatment of metals. From the area of electricity and electronics, basic electronics was selected as an elective. Finally, from the area of general technology, public speaking was considered to be a preferred elective.

Analyst, Gauge Design and Planning A total of 19 different companies expressed their desires with regard to the curricular training of the Analyst, Gauge Design and Planning, Figure 90. They selected for this occupation one of the most rigorous and diversified curricula within the area of mechanical technology. Their course selections were made from the areas of mathematics, chemistry, physics, metals, electricity, mechanics, and general technology. These are all of the general areas of technology listed in this study. However, particular emphasis was placed upon the areas of mathematics, physics, metals, and mechanics.

The respondents considered it essential to have mathematics courses in algebra, trigonometry, plane geometry, solid geometry, descriptive geometry, analytic geometry, logarithms and slide rule usage. Also considered essential was physics instruction in mechanics. Strength of materials and heat treatment of metals were the needed courses selected from the area of metals. The mechanics courses considered to be essential for this occupation were technical drafting, tool and gauge design, machine theory and mechanics, and machine shop practices.

The respondents selected as advisable, course work from the same areas of mathematics, physics, metals, and mechanics, plus a few additional courses from the area of general technology. In mathematics, they considered calculus to be advisable. Physics instruction in electricity and magnetism should also be included, as well as principles of metallography from the area of metals.

FIGURE 90: ANALYST, GAUGE DESIGN AND PLANNING



The mechanics courses chosen were technical illustrating, machine design, precision measuring instruments, structural design, and fluid dynamics and hydraulics. A few courses from the area of general technology were also deemed advisable. These were analysis of experimental data, technical writing, public speaking, and professional relations.

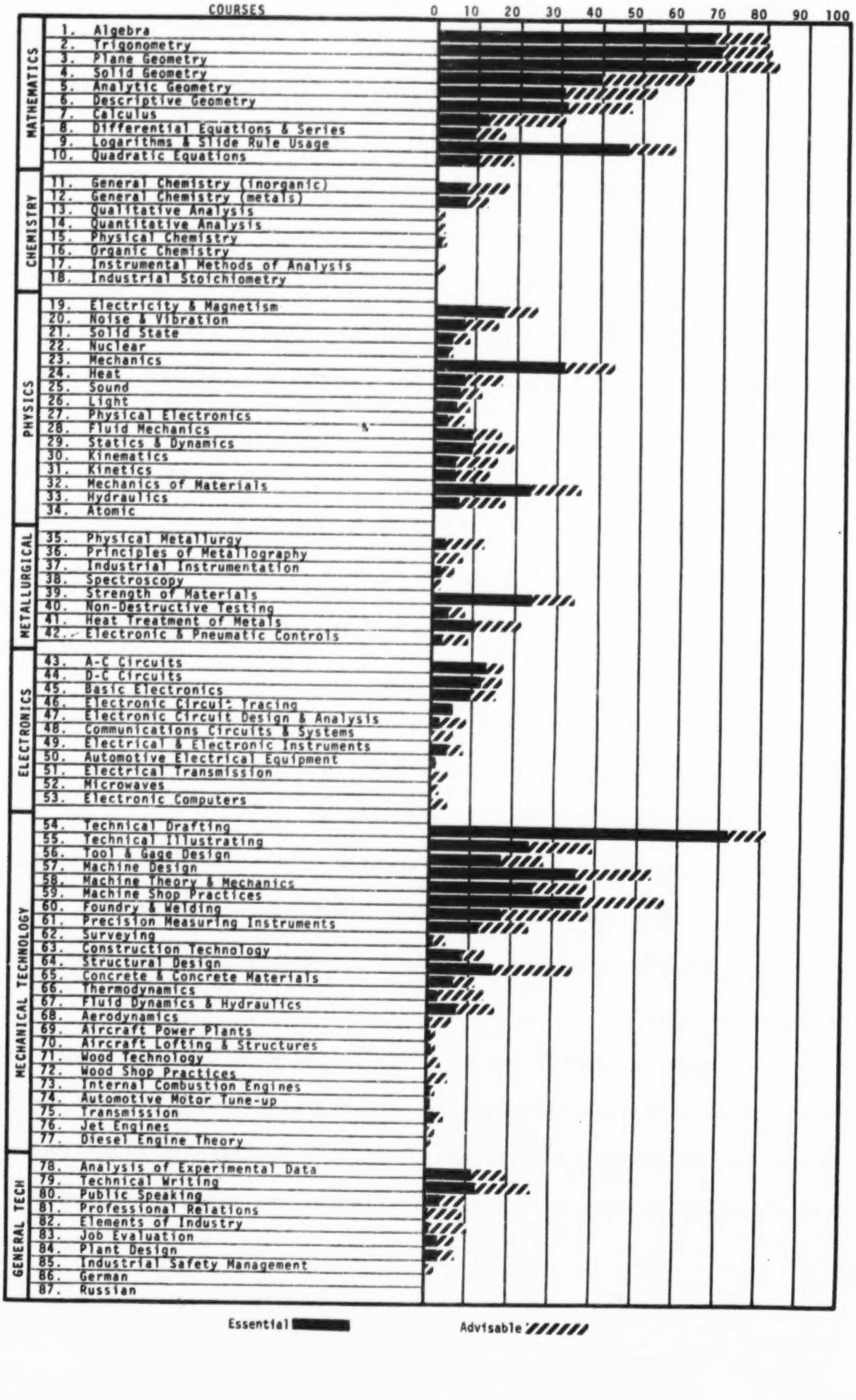
Within the classification of preferred electives, there were a large number of courses representing all of the general areas of technology. From the area of mathematics, differential equations and series and quadratic equations were selected. General chemistry (both inorganic and metals) was selected along with physics instruction in heat, fluid mechanics, statics and dynamics, mechanics of materials, and hydraulics. From the area of metals, the preferred selections were physical metallurgy, industrial instrumentation, and non-destructive testing. From the area of electricity and electronics, basic electronics was suggested. The mechanics courses chosen for this classification were foundry and welding, construction technology, and thermodynamics. Finally chosen for this classification from the area of general technology, were elements of industry and industrial safety management.

Engineering Drawing Checker Some 99 companies reported their curricular preferences with regard to training for the position of Engineering drawing Checker, Figure 91. They chose a relatively simple curriculum emphasizing primarily the areas of mathematics and mechanics. Physics training was shown to be of less importance, and one selection was made from the area of metals.

The essential course work for the Engineering Drawing Checker consisted of a basic mathematics background including algebra, trigonometry, plane geometry, and logarithms and slide rule usage, plus a course in technical drafting.

More advanced work in mathematics was considered advisable. This would include courses in solid geometry, analytic geometry, and descriptive

FIGURE 91: ENGINEERING DRAWING CHECKER



geometry. Physics instruction in mechanics was also advisable. The additional mechanics courses considered to be advisable additions to this curriculum were machine design and machine shop practices.

A course in calculus was selected as a preferred elective for this occupation along with physics instruction in mechanics of materials. From the area of metals, the respondents preferred as elective a course in strength of materials. The additional mechanics courses suggested were technical illustrating, machine theory and mechanics, foundry and welding, and structural design.

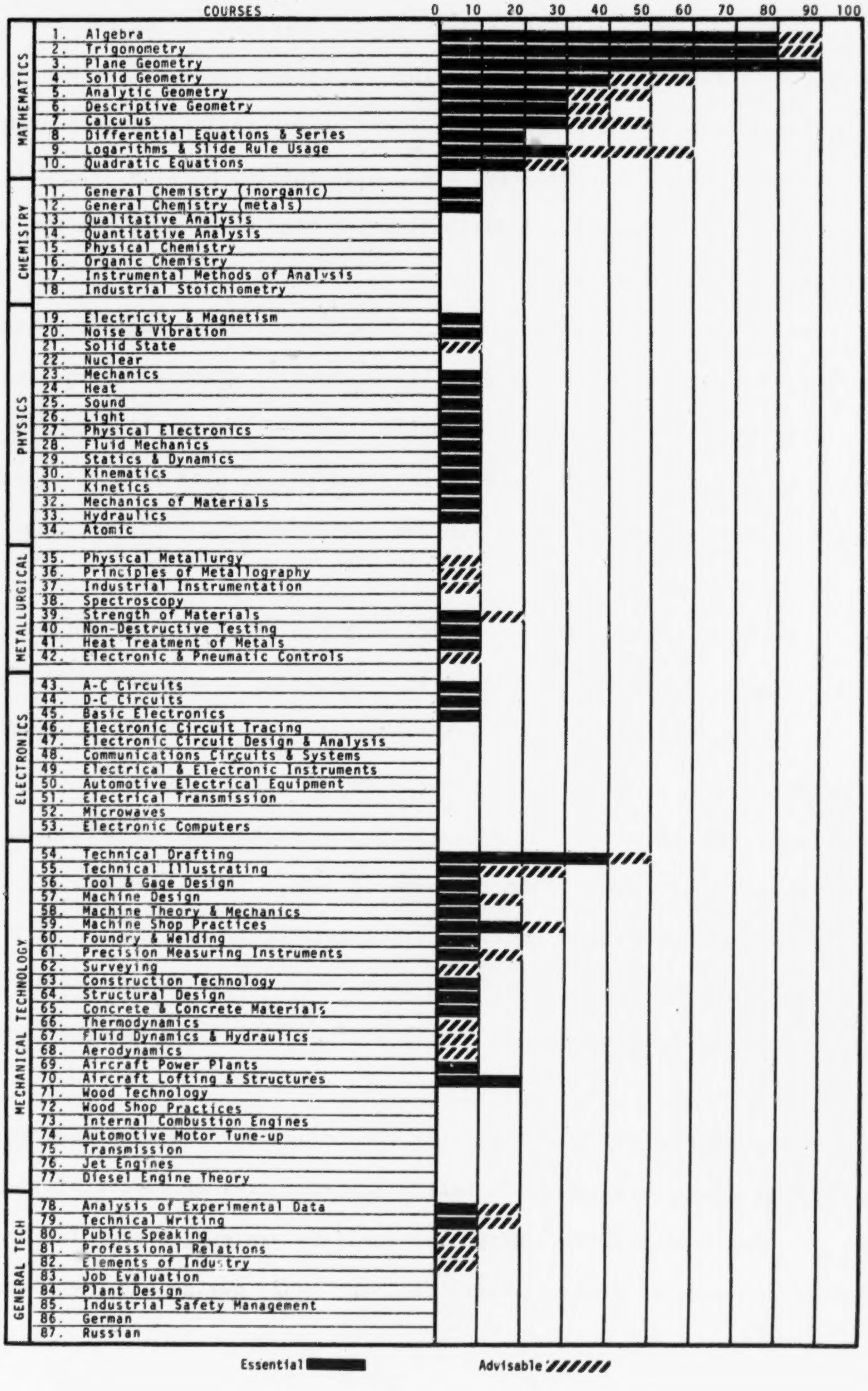
Loftsman There were 10 companies which made recommendations with regard to the curricular needs of the Loftsman, Figure 92. They outlined what might be described as a skeletal curriculum consisting of course work in mathematics and mechanics only. Particular emphasis was given to the area of mathematics.

The essential mathematics background for the Loftsman consisted of algebra, trigonometry, plane geometry, and solid geometry. In addition to this, the only essential course was technical drafting.

All of the course work which the respondents indicated as advisable additions to this essential background were selections from the area of mathematics. These included analytic geometry, descriptive geometry, calculus, and logarithms and slide rule usage.

The chosen electives for this occupation were once again limited to the areas of mathematics and mechanics. The preferred elective from the area of mathematics was quadratic equations. Additional suggested selections from the area of mechanics were technical illustrating and machine shop practices.

FIGURE 92: LOFTSMAN



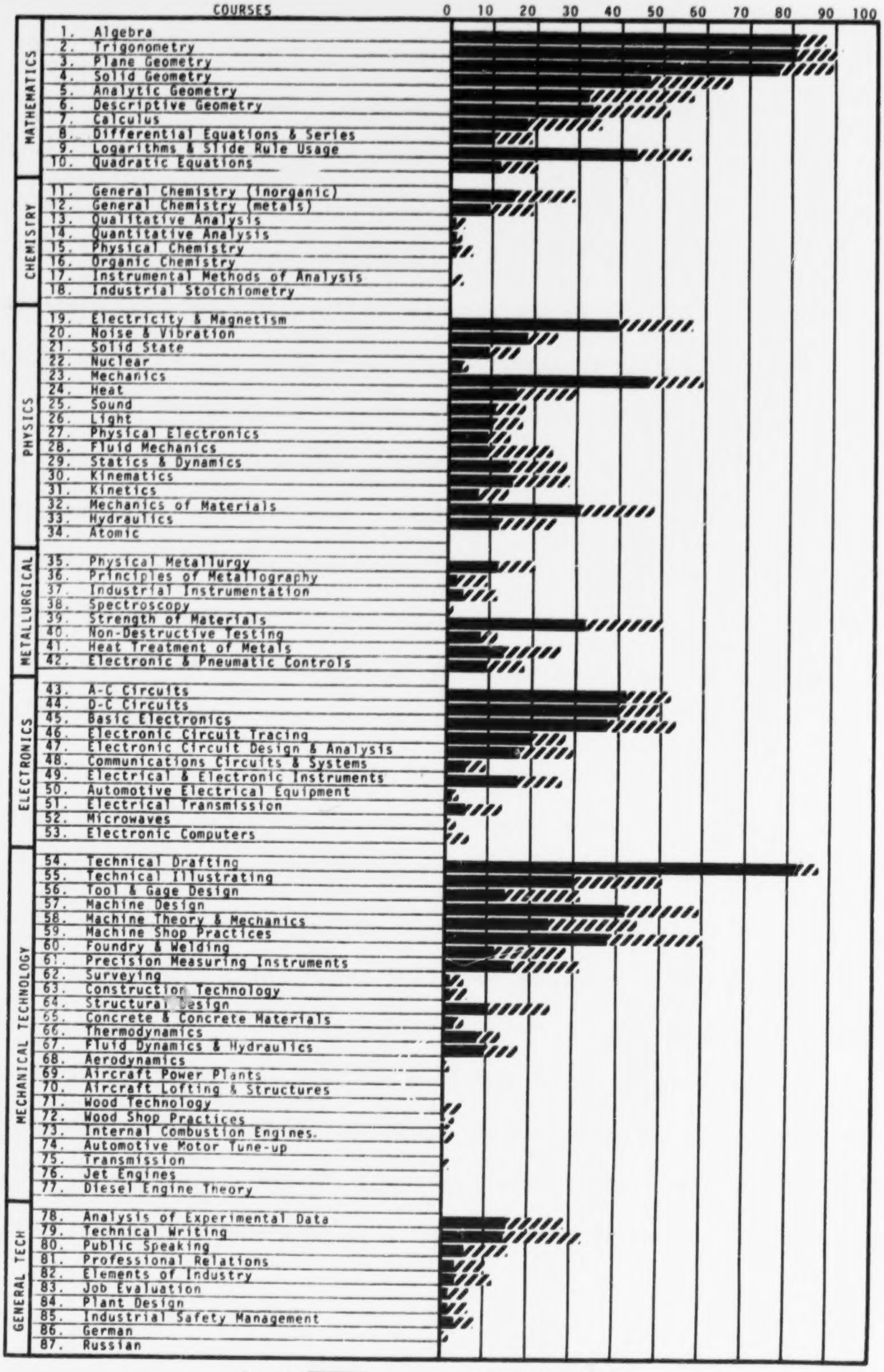
Design Draftsman, Electromechanical A total of 125 companies expressed their judgments with regard to the curricular needs of the Design Draftsman, Electromechanical, Figure 93. Their course selections were primarily from four general areas of technology, i.e., mathematics, physics, electricity and electronics, and mechanics. Additional selections were made from the areas of metals and general technology.

The mathematics background which these respondents considered essential for this occupation consisted of algebra, trigonometry, plane geometry, solid geometry, and logarithms and slide rule usage. Physics instruction in mechanics was needed, as well as courses in AC circuits and DC circuits from the area of electronics. The essential courses from the mechanics area were technical drafting and machine design.

Considered to be advisable additions to this basic or essential listing of courses were other selections from the areas of mathematics, physics, metals, electricity and electronics, and mechanics. The advisable mathematics additions were analytic geometry and descriptive geometry. In the area of physics instruction, it was indicated that electricity and magnetism and mechanics of materials should be included. From the area of metals, the respondents indicated that strength of materials was advisable along with basic electronics from the area of electricity and electronics. The mechanics courses deemed advisable were technical illustrating, machine theory and mechanics, and machine shop practices.

Among the electives preferred by the respondents were courses in calculus and in physics training, in heat. From the area of electricity and electronics, electronic circuit design and analysis was suggested. The preferred electives in the area of mechanics were tool and gauge design and precision

FIGURE 93: DESIGN DRAFTSMAN, ELECTROMECHANICAL



measuring instruments. Finally, from the area of general technology, technical writing was selected as a preferred elective.

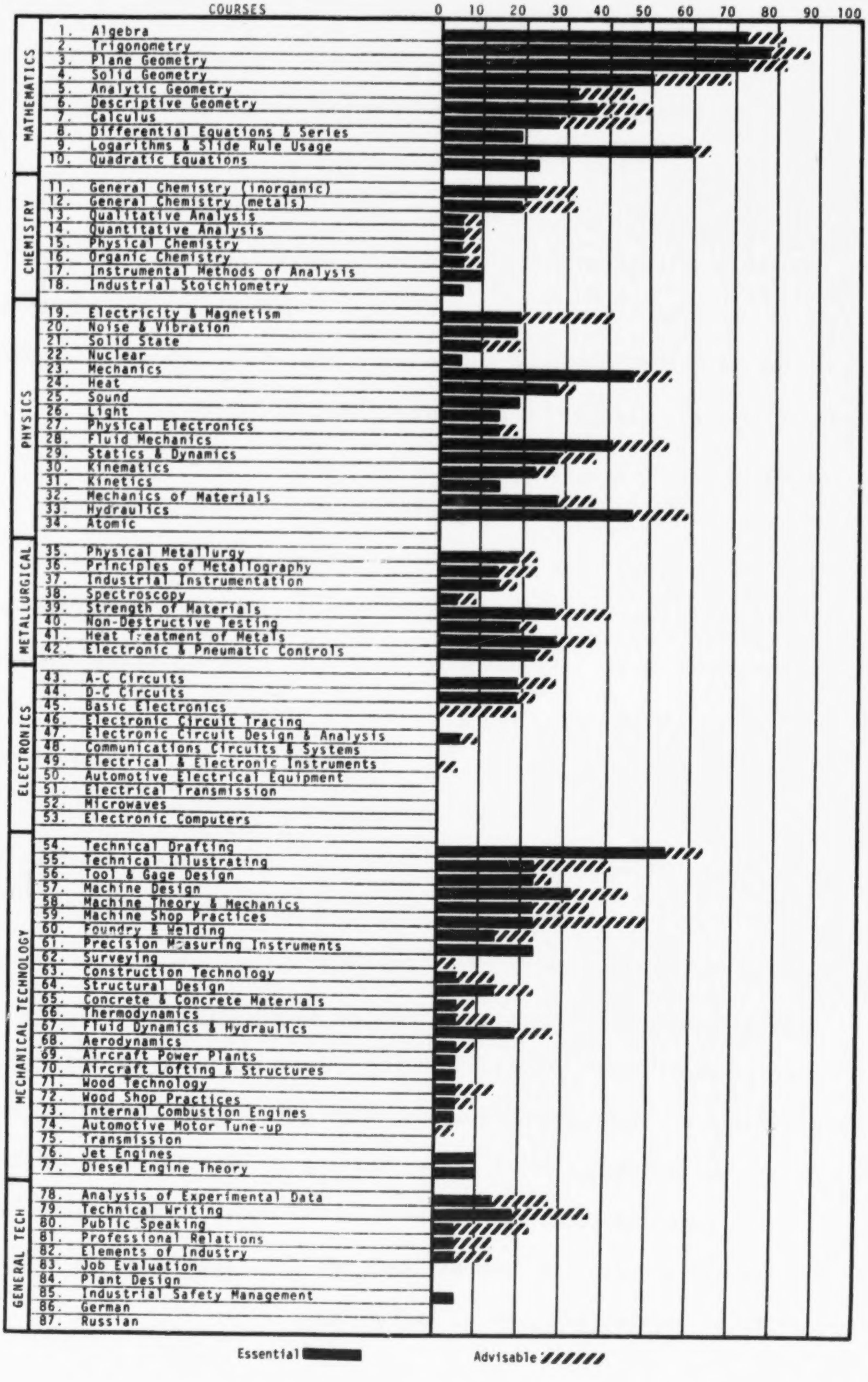
Design Draftsman, Hydraulic Linkage The 22 companies which responded with regard to the Design Draftsman, Hydraulic Linkage, Figure 94, indicated that they would desire for this occupation a curriculum which is basically similar to that just outlined for the Electromechanical Design Draftsman. There were some substantial differences, however, in that no course selections were made from the area of electricity and electronics, but basic course work in the area of chemistry was suggested for this occupation.

The essential background for this occupation consists of some training in the areas of machematics and physics, plus a course in technical drafting. The mathematics which this individual must have is algebra, trigonometry, plane geometry, solid geometry, and logarithms and slide rule usage. He must also have physics instruction in mechanics, fluid mechanics and hydraulics. From the area of mechanics, technical drafting was considered essential.

The additional course work in the area of mathematics which was considered an advisable addition to this curriculum was analytic geometry, descriptive geometry, and calculus. Physics instruction in electricity and magnetism was also deemed advisable, as was strength of materials from the area of metals. The advisable mechanics courses were technical illustrating, machine design, and machine shop practices.

The electives which the respondents would prefer for this curriculum were selections from the areas of chemistry, physics, metals, mechanics, and general technology. First of all, general chemistry (both inorganic and metals) was preferred as an elective. Further physics training in heat, statics and

FIGURE 94: DESIGN DRAFTSMAN, HYDRAULIC LINKAGE



dynamics, and mechanics of materials was suggested. From the area of metals, heat treatment of metals was selected along with machine theory and mechanics from the area of mechanics. In the area of general technology, technical writing was also considered to be a preferred elective.

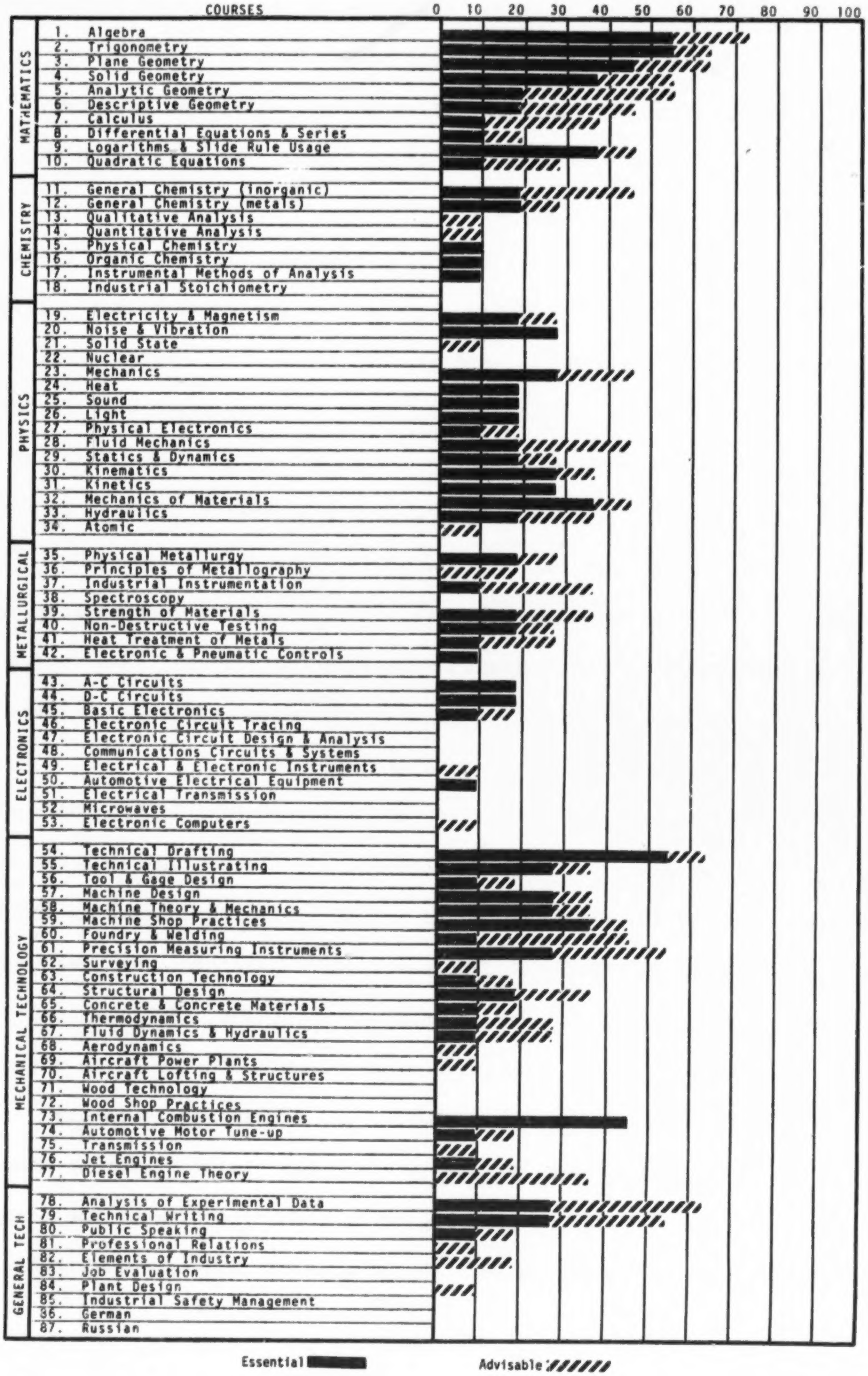
Design Draftsman, Ram Jet Engine Only three companies responded with regard to the Design Draftsman, Ram Jet Engine. Their responses indicated that this program of study should emphasize the areas of mathematics and mechanical technology. However, they did select some basic courses in the areas of physics, metals, electricity and electronics, and miscellaneous technology.

Design Draftsman, Rocket Engine A total of four companies made course selections for the occupation of Design Draftsman, Rocket Engine. Their selections were similar to those of the Design Draftsman, Ram Jet Engine. The general emphasis was placed upon the areas of mathematics and mechanical technology instruction, but there were also some selections made from the areas of physics, basic metals, basic electricity, and miscellaneous technology.

Steam Turbine Design Technician With regard to the Steam Turbine Design Technician, four companies made judgments regarding the curricular training needed. Once again, the areas which were emphasized were those of mathematics and mechanical technology. However, there was indication of some need for training in physics, metals, electricity, and general technology.

Engine Development Technician (Internal Combustion) A total of 11 companies made judgments with reference to the curricular needs of the Engine Development Technician (Internal Combusion), Figure 95. They outlined a program with relatively few essentials but a longer listing of advisable courses of study. While the basic emphasis was placed upon the areas of mathematics and mechanics, advisable and elective courses were selected also from the areas of chemistry, physics, metals, and general technology.

FIGURE 95: ENGINE DEVELOPMENT TECHNICIAN (INTERNAL COMBUSTION)



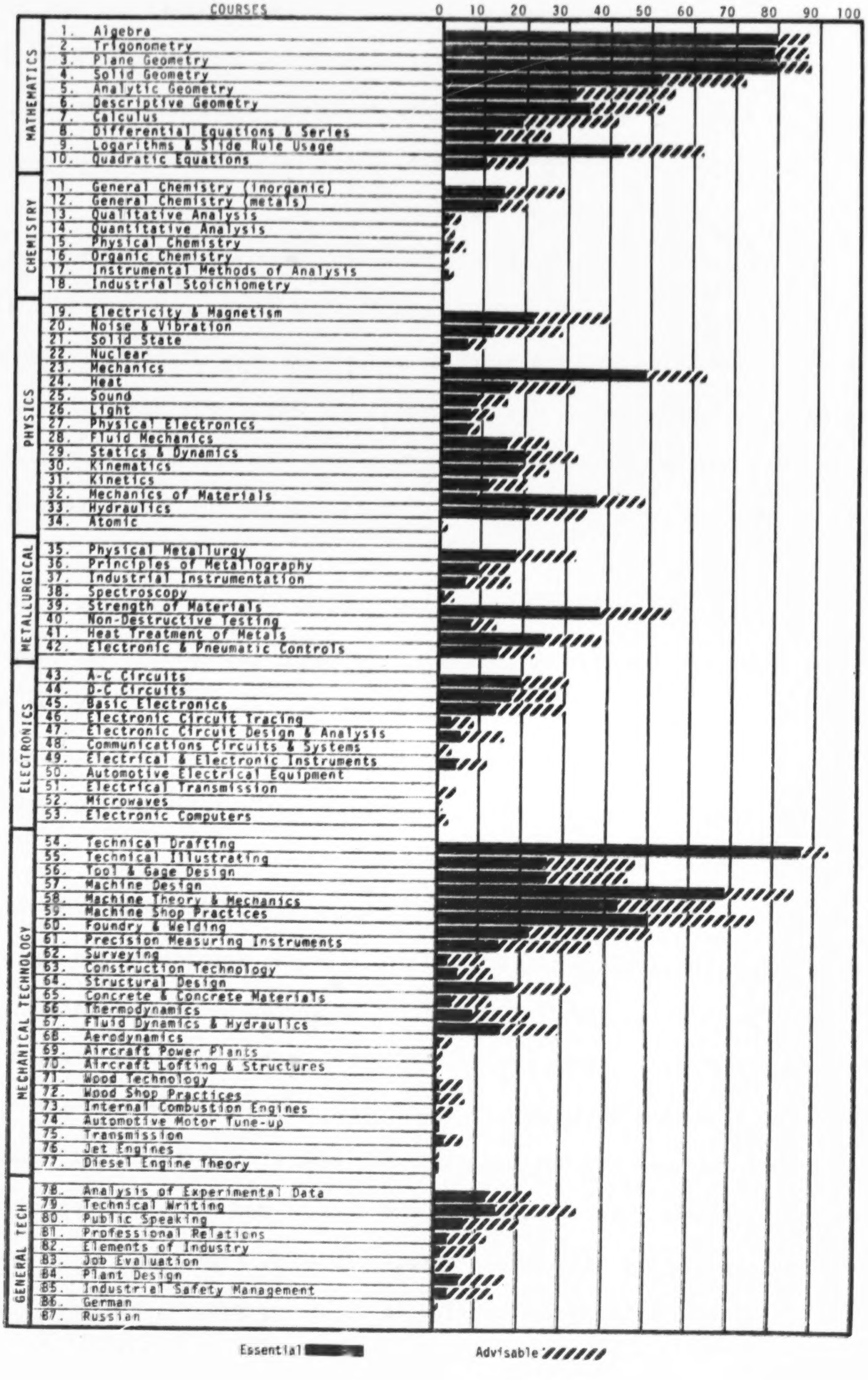
The only courses deemed essential for this occupation were those selected from the areas of mathematics and mechanics. The selections from the area of mathematics were algebra, trigonometry, and plane geometry. The essential course work from the area of mechanics consisted of technical drafting and internal combustion engines.

In addition to these essential courses, the respondents selected a relatively long list of advisable courses from the areas of mathematics, chemistry, physics, mechanics, and general technology. First, from the area of mathematics, it was considered advisable to have course work in solid geometry, analytic geometry, descriptive geometry, and logarithms and slide rule usage. General chemistry (inorganic) and physics training in mechanics, fluid mechanics, and mechanics of materials were deemed advisable. From the area of mechanics, this curriculum should also include machine shop practices, foundry and welding, and precision measuring instruments. Two courses from the area of general technology were also considered advisable. These were analysis of experimental data and technical writing.

The respondents indicated that a fairly long listing of courses should come under the heading of preferred electives. Calculus was selected from the area of mathematics. Physics instruction in kinematics and hydraulics was also suggested. The preferred electives chosen from the area of metals were industrial instrumentation and strength of materials. Finally, those chosen from the area of mechanics were technical illustrating, machine design, machine theory and mechanics, structural design, and diesel engine theory.

Design Draftsman, Machinery A total of 181 different companies expressed their preferences with regard to the curriculum of the Design Draftsman, Machinery, Figure 96. The program of courses which their responses

FIGURE 96: DESIGN DRAFTSMAN, MACHINERY



indicated was in many respects similar to those already outlined for the Design Draftsman, Electromechanical, and the Design Draftsman, Hydraulic Linkage. Primary emphasis was given once again to the areas of mathematics, physics, and mechanics. Training in the areas of metals, electricity and electronics, and general technology was of secondary importance.

The essential course work for the Design Draftsman, Machinery, was selected from the areas of mathematics, physics, and mechanics. First of all, from the area of mathematics, the selected essentials were algebra, trigonometry, plane geometry, solid geometry, and logarithms and slide rule usage. Physics instruction in mechanics was needed. The necessary background in mechanics consisted of technical drafting, machine design, machine theory and mechanics, and machine shop practices.

The respondents considered it advisable to have mathematics courses in analytic geometry, descriptive geometry, and calculus, as well as further physics instruction in electricity and magnetism, and mechanics of materials. From the area of metals, they indicated strength of materials to be advisable. The advisable course work in the area of mechanics was technical illustrating, tool and gauge design, and foundry and welding.

The electives suggested by the responses were selections from the areas of physics, metals, electricity and electronics, mechanics, and general technology. The elective physics instruction suggested was heat, statics and dynamics, and hydraulics. From the area of metals, physical metallurgy and heat treatment of metals were suggested. In the area of electricity and electronics, AC circuits and basic electronics were within the classification of preferred electives. Selections from the area of mechanics were precision measuring instruments and structural design. Finally, from the area of general technology, technical writing was considered to be a preferred elective.

Layout Man and Checker A total of 76 different companies expressed their desires with regard to the training of the Layout Man and Checker, Figure 97. They chose for this occupation a relatively simple listing of courses which was almost identical to that outlined for the Engineering Drawing Checker.

The only course work which the Layout Man and Checker must have is technical drafting and a basic background in mathematics. The essential mathematics courses are algebra, trigonometry, and plane geometry.

The respondents deemed it advisable to add this basic mathematics background: solid geometry, analytic geometry, descriptive geometry, and logarithms and slide rule usage. Physics instruction in mechanics was also considered to be advisable; and from the area of mechanics, they chose machine design and machine shop practices as advisable courses.

Calculus was suggested as a preferred elective, along with physics instruction in mechanics of materials. From the area of metals, strength of materials was selected. The additional mechanics course work, which came under the classification of preferred electives, are four courses in technical illustrating, tool and gauge design, machine theory and mechanics, and foundry and welding.

Design Checker Curricular recommendations were made by a total of 47 companies with regard to the curricular needs of persons preparing for work in industry as Design Checker, Figure 98. The curriculum which they recommended was a little more demanding than that outlined for the Engineering Drawing Checker and the Layout Man and Checker.

The courses selected as essential for this occupation come within the general areas of mathematics, metals, and mechanics. The necessary mathematics

FIGURE 97: LAYOUT MAN AND CHECKER

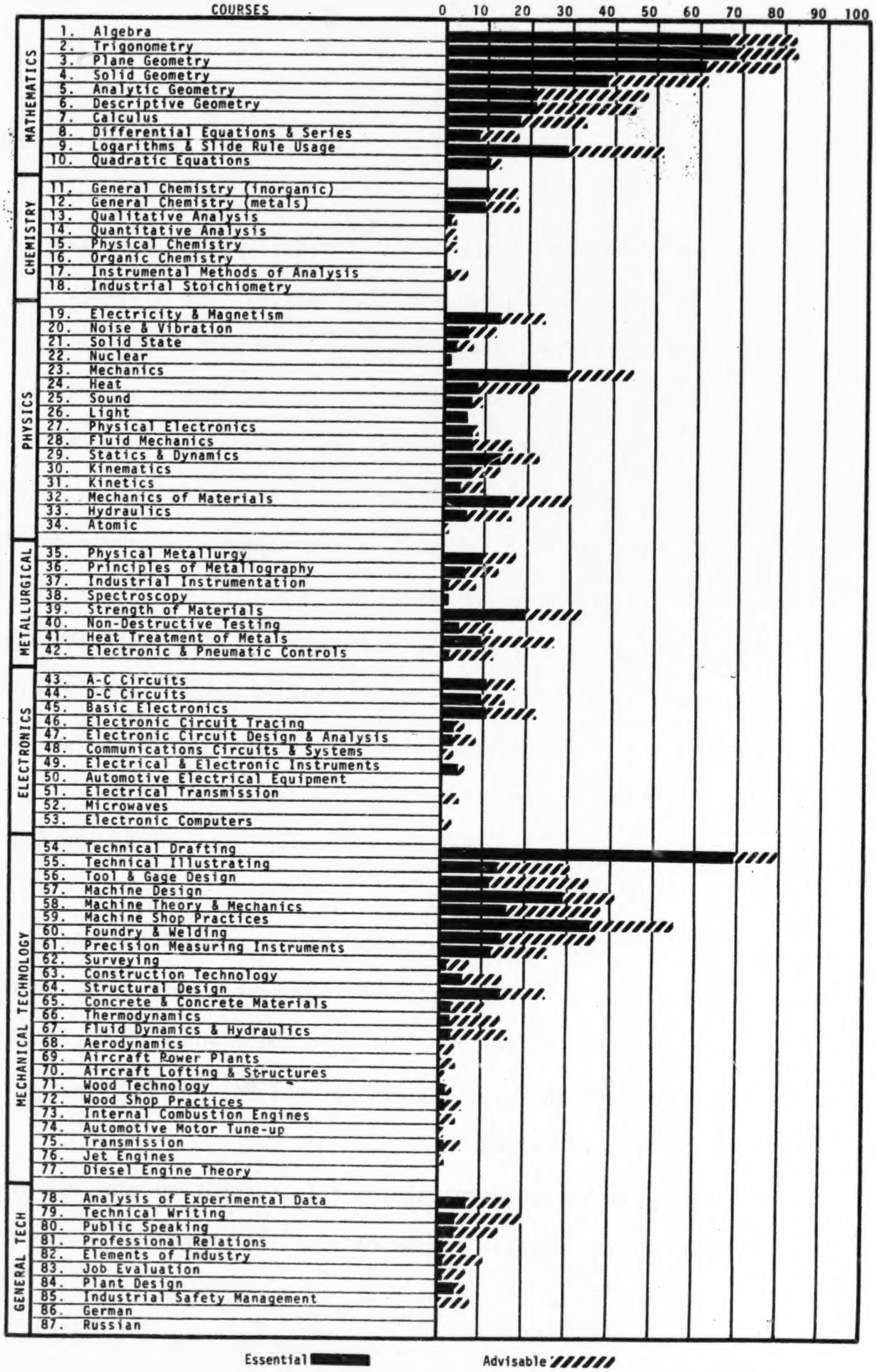
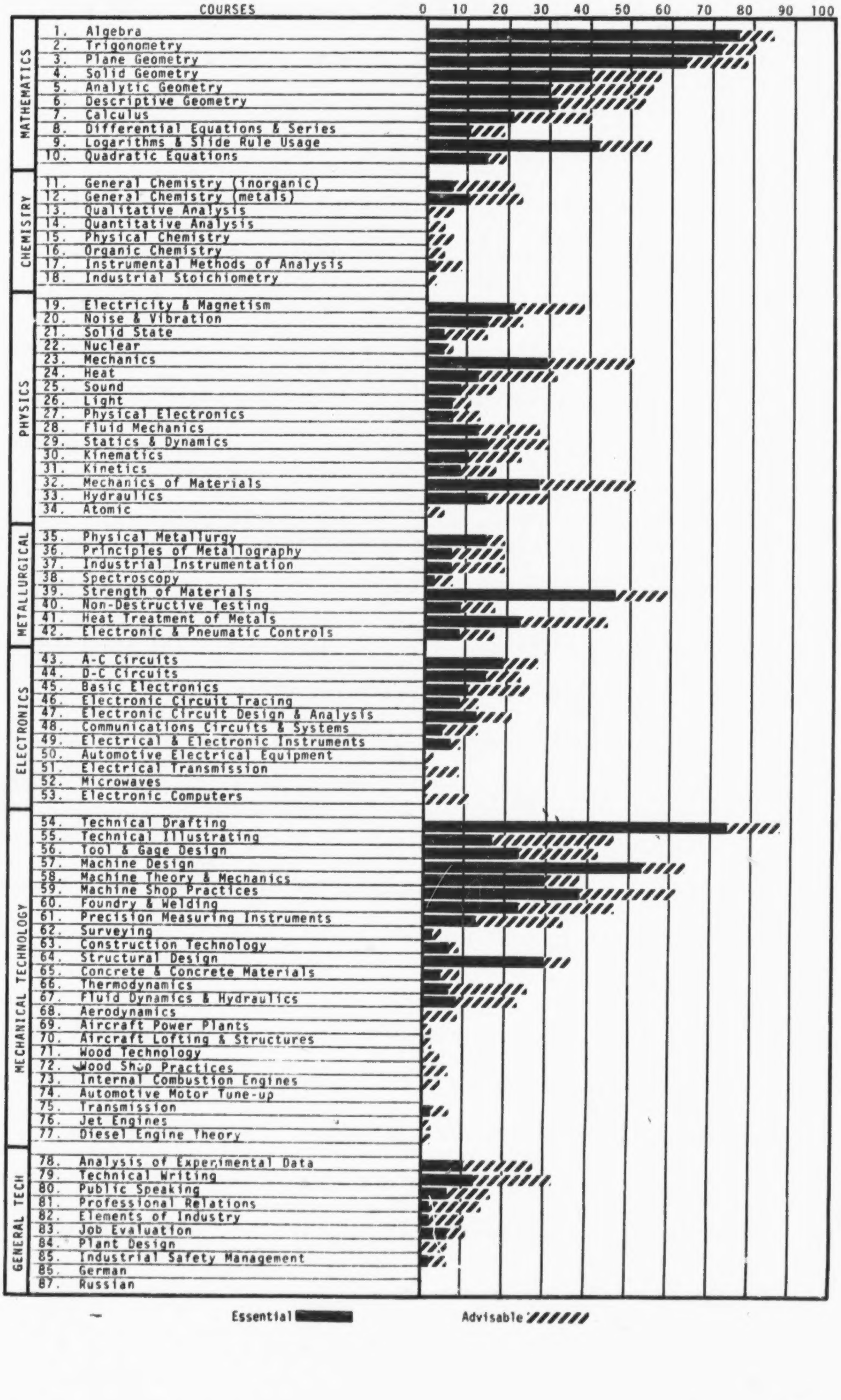


FIGURE 98: DESIGN CHECKER



background consists of algebra, trigonometry, plane geometry, solid geometry, and logarithms and slide rule usage. From the area of metals, strength of materials was also considered a necessity. Two courses from the area of mechanics were deemed essential. These were technical drafting and machine design.

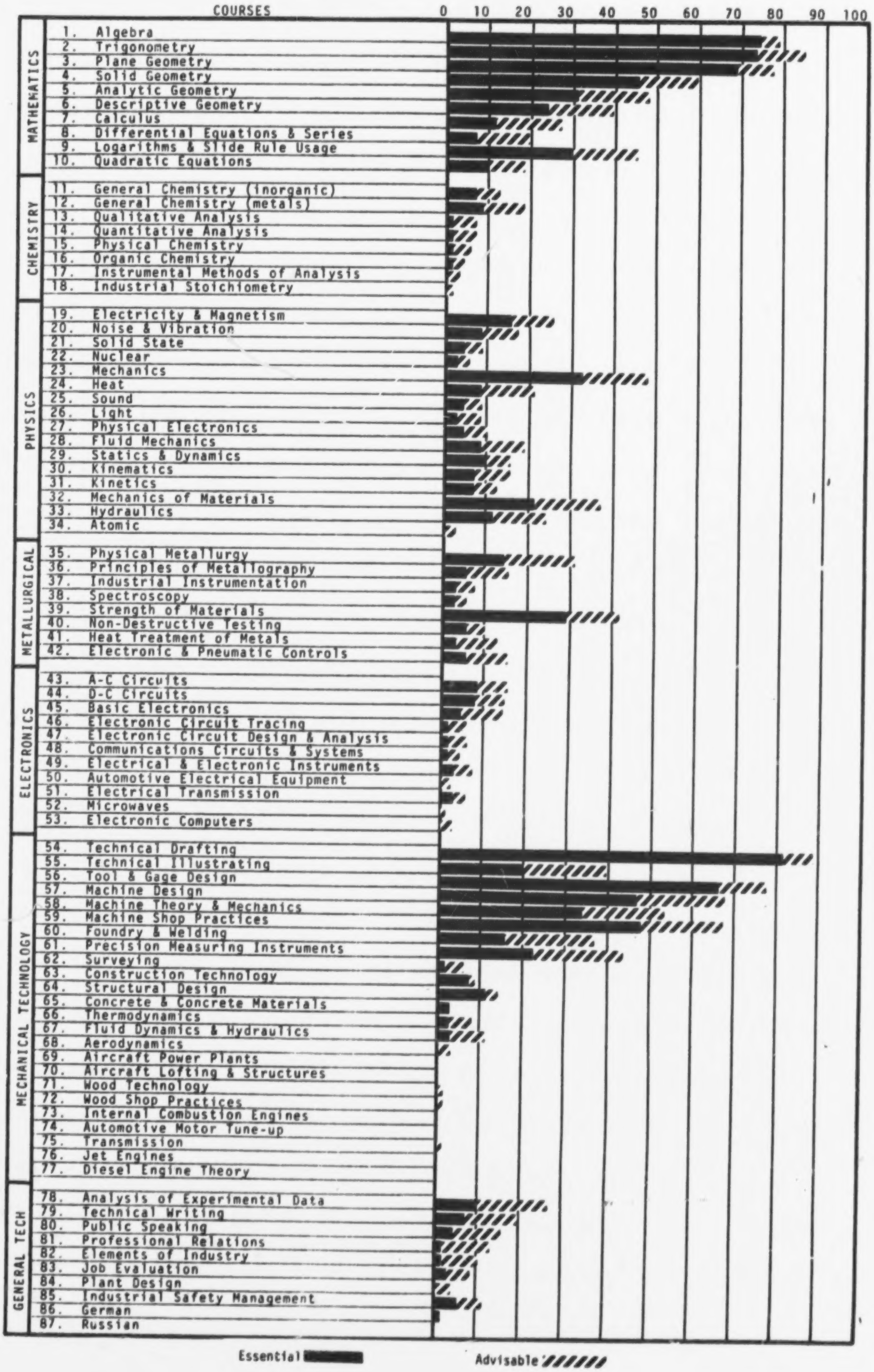
Some additional mathematics training was considered advisable. This was course work in analytic geometry, descriptive geometry, and calculus. It was felt that physics instruction in mechanics and mechanics of materials should also be included. From the area of metals, heat treatment of metals was considered advisable. The additional work in the area of mechanics which was considered advisable included courses in technical illustrating, tool and gauge design, machine shop practices, and foundry and welding.

Physics instruction in heat was considered to be a preferred elective, along with mechanics courses in machine theory and mechanics, precision measuring instruments, and instrumental design. From the area of general technology, technical writing was also selected as a preferred elective.

Die Designer The 71 companies which expressed their desires with regard to the curricular training of the Die Designer, Figure 99, selected for this position a curriculum much like that already outlined for the Tool Designer. Once again, the course needs were in the four areas of mathematics, physics, metals, and mechanics, with special emphasis being placed upon the two areas of mathematics and mechanics.

The courses which the respondents indicated to be essential were within the areas of mathematics and mechanics. The essential mathematics background consisted of algebra, trigonometry, plane geometry, and solid geometry. The course work which should be included from the area of mechanics is technical drafting, tool and gauge design, machine design, and machine shop practices.

FIGURE 99: DIE DESIGNER



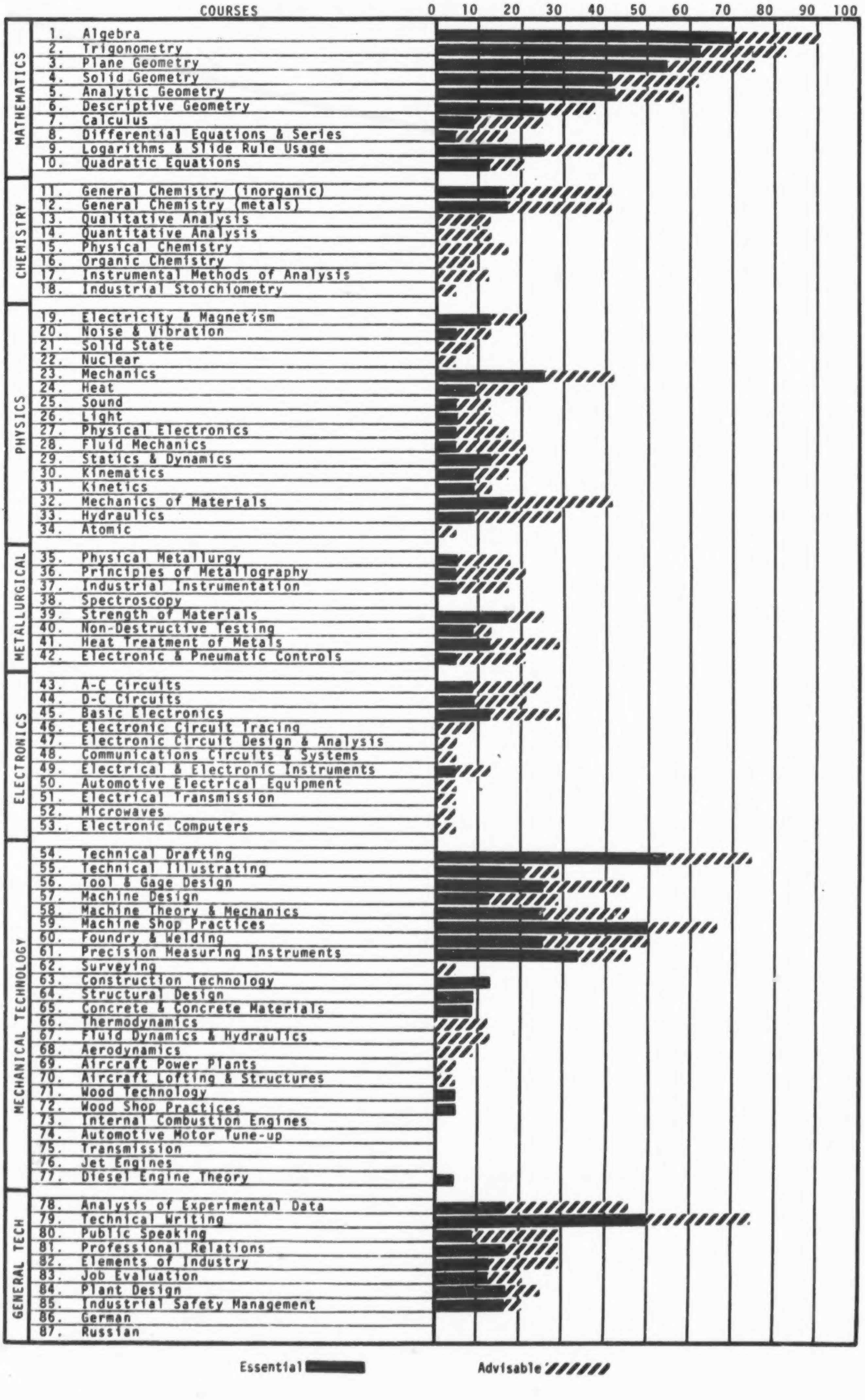
Added to these basic essentials were a number of courses from the areas of mathematics, physics, metals, and mechanics which were considered to be advisable. It was felt that this curriculum should include from the area of mathematics analytic geometry and logarithms and slide rule usage. Physics training in mechanics was advisable, as well as metals training in strength of materials. The mechanics courses coming within this classification were machine theory and mechanics and precision measuring instruments.

The preferred electives in this curriculum were selections from the same four general areas of mathematics, physics, metals, and mechanics. Descriptive geometry was selected from the area of mathematics; physics training and mechanics of materials were suggested, along with physical metallurgy, from the areas of metals. The elective mechanics courses which were preferred were technical illustrating and foundry and welding.

Engineering Designer, Aircraft Structures A total of nine companies recommended the curricular training which they felt would be appropriate for the Engineering Designer, Aircraft Structures. These companies indicated that a very strong mathematics background was essential. This would include calculus and advanced geometry course work. They felt that some instruction in physics was needed, and they selected additional courses from the areas of metallurgical technology, mechanical technology, and general technology. Receiving particular emphasis were courses such as technical drafting, strength of materials, machine design, and structural design. Of course, advanced courses dealing more specifically with aircraft technology were also considered appropriate.

Process Description Writer A total of 24 companies expressed their judgments with regard to the curricular needs of personnel training for the position of Process Description Writer in industry, Figure 100. They chose

FIGURE 100: PROCESS DESCRIPTION WRITER



for this occupation what might be described as a rather general curriculum with relatively few essential course needs, but a longer listing of advisable courses which were selected from several of the general areas of technology.

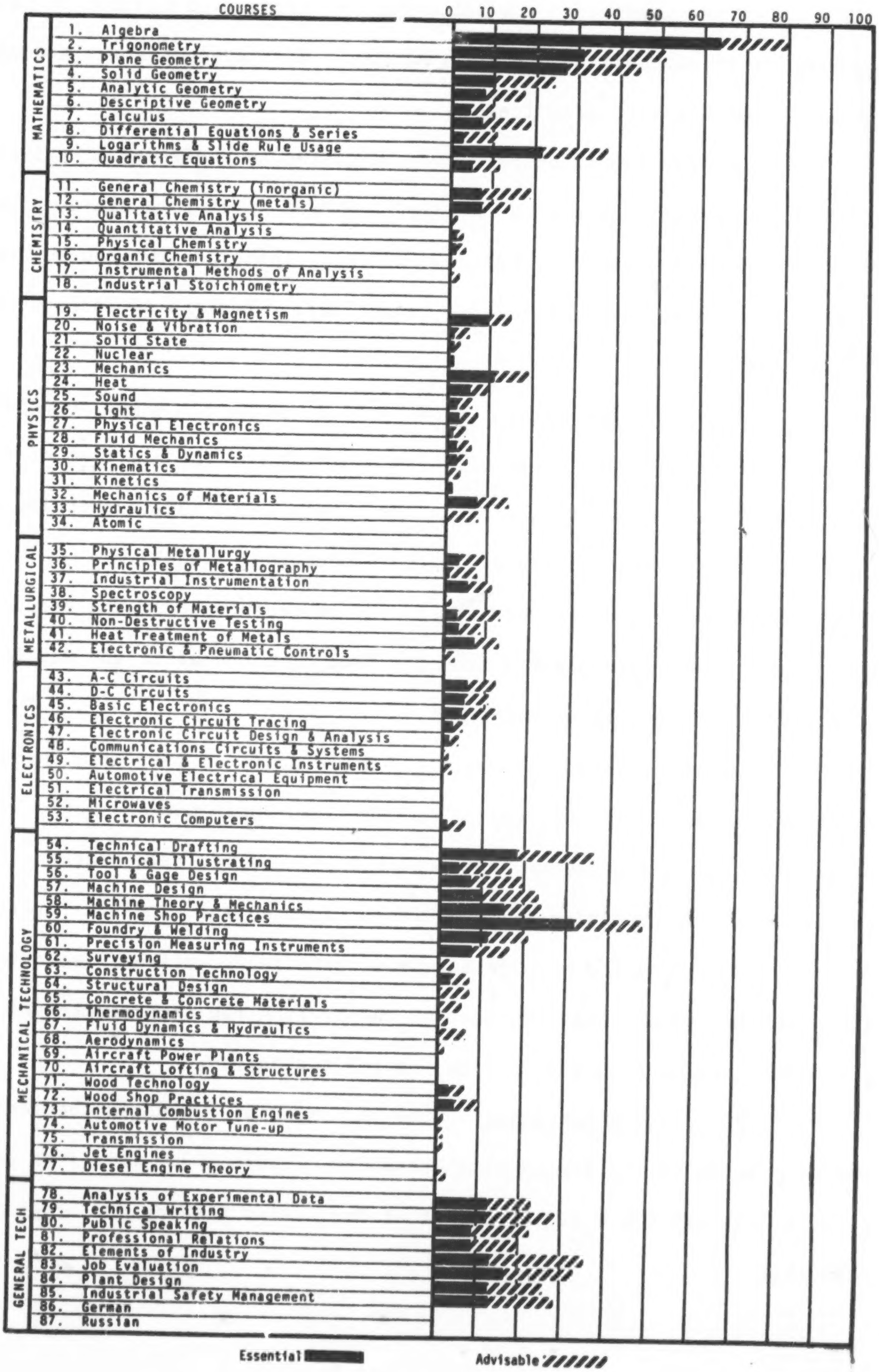
Besides technical writing, the essential course work in this curriculum consisted of selections from the areas of mathematics and mechanics. First, from the area of mathematics, the selections were algebra, trigonometry, plane geometry, solid geometry, and analytic geometry. The essential mechanics courses were technical drafting and machine shop practices.

The advisable courses for this curriculum came from a number of the general areas of technology, including mathematics, chemistry, physics, mechanics, and general technology. From the area of mathematics, it was considered advisable to include logarithms and slide rule usage. General chemistry (both inorganic and metals) was considered to be advisable, along with physics instruction in mechanics and mechanics of materials. The mechanics courses which came within this classification were tool and gauge design, machine theory and mechanics, foundry and welding, and precision measuring instruments. In the area of general technology, it was also considered advisable to have a course in the analysis of experimental data.

Only one course came within the classification of preferred electives: descriptive geometry.

Production Planner A total of 137 different companies made judgments with regard to the curricular needs of the Production Planner, Figure 101. The curriculum developed from their judgments was one of the simplest of those described for the occupations included in this study. Algebra was the only essential course in this curriculum.

FIGURE 101: PRODUCTION PLANNER



It was considered advisable for the Production Planner to have training in trigonometry and plane geometry. Also advisable was a mechanics course in machine shop practices.

Four additional courses were suggested as preferred electives. The first was mathematics training in logarithms and slide rule usage. The second was a mechanics course in technical drafting. The other two courses were selections from the area of general technology: elements of industry and job evaluation.

Production Estimator There were 91 companies which responded with regard to the curricular needs of those training for the position of Production Estimator, Figure 102. According to their responses, this curriculum would be less complex than that outlined for the Production Planner.

Only two courses were considered as essential for the Production Estimator. These were algebra from the area of mathematics and machine shop practices from the area of mechanics.

Some additional mathematics and mechanics courses were considered to be advisable. From the area of mathematics, these courses would include trigonometry, plane geometry, and logarithms and slide rule usage. The mechanics course which the companies felt should be included was technical drafting.

Three courses were selected as preferred electives: solid geometry from the area of mathematics, machine theory from the area of mechanics, and technical writing from the area of general technology.

Engineering Scheduler Some 41 companies evaluated the technical training needs of the Engineering Scheduler, Figure 103. This less complex program of study was similar to that of Production Planner and Production Estimator.

FIGURE 102: PRODUCTION ESTIMATOR

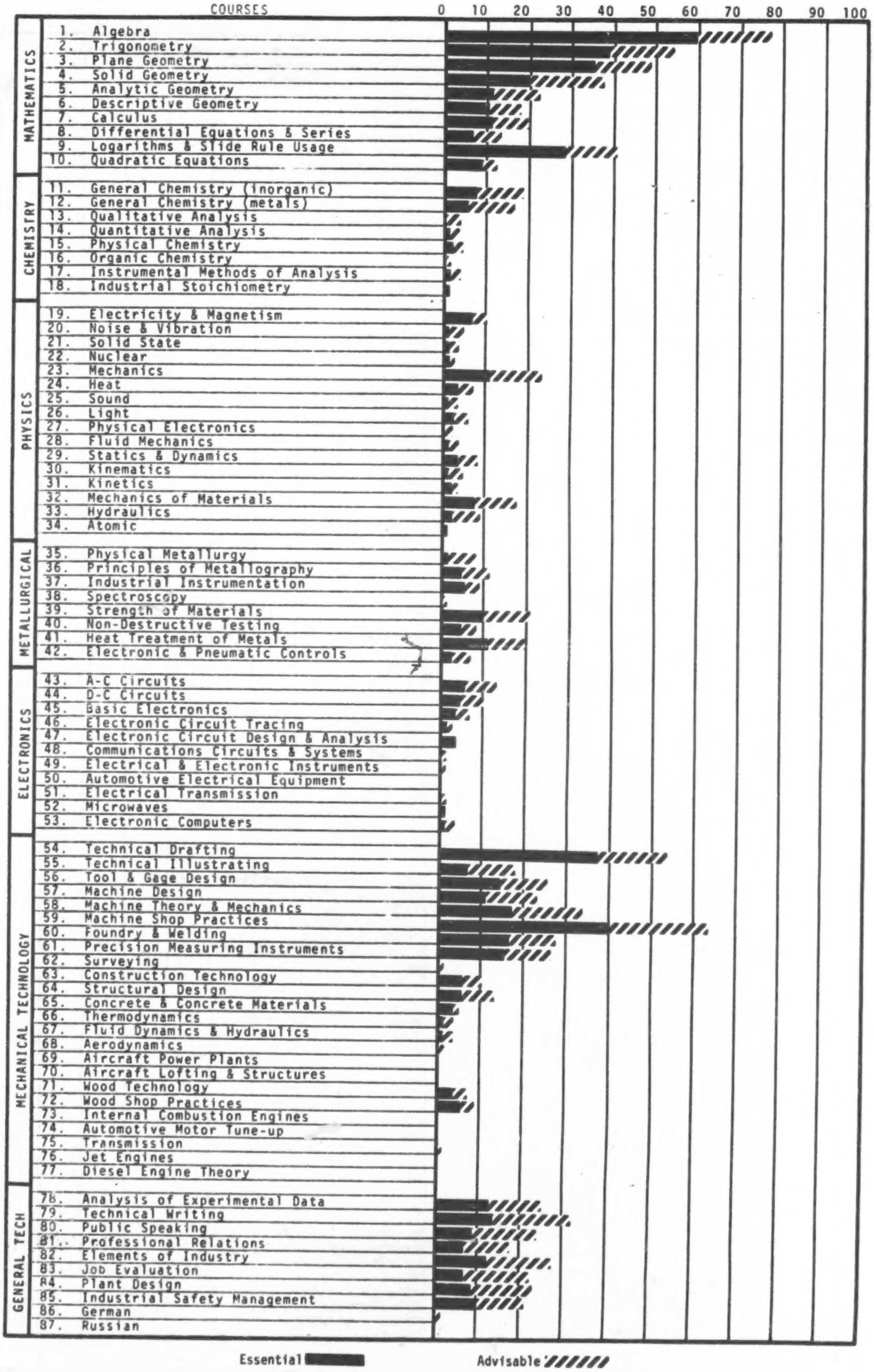
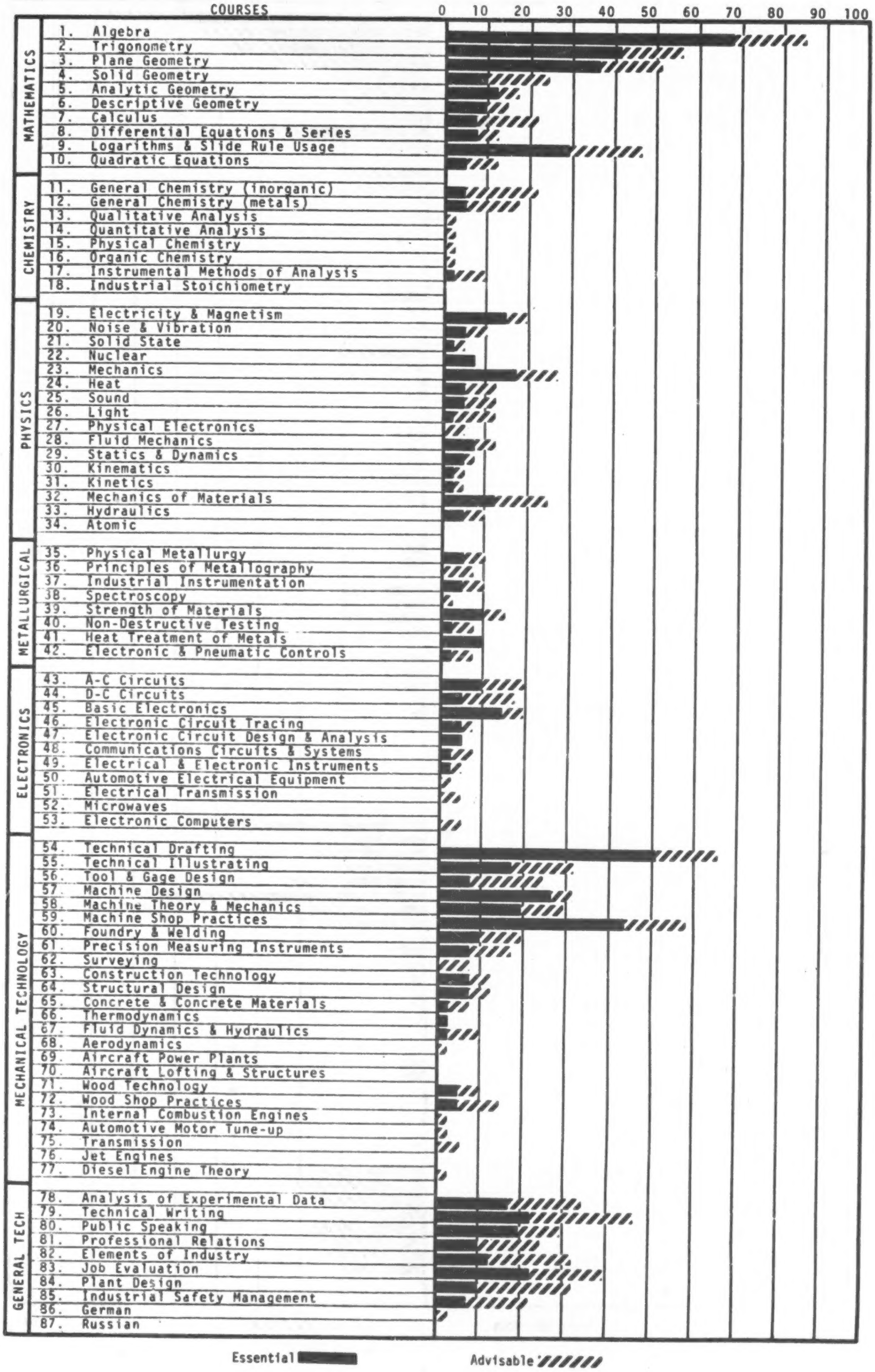


FIGURE 103: ENGINEERING SCHEDULER



The essential course needs of the Engineering Scheduler were within the areas of mathematics and mechanics. The mathematics courses needed were algebra and trigonometry. The essential mechanics courses were technical drafting and machine shop practices.

The courses which were considered to be advisable for this curriculum were in the areas of mathematics and general technology. It was felt that mathematics training in plane geometry and logarithms and slide rule usage should be included, and a course in technical writing was considered advisable.

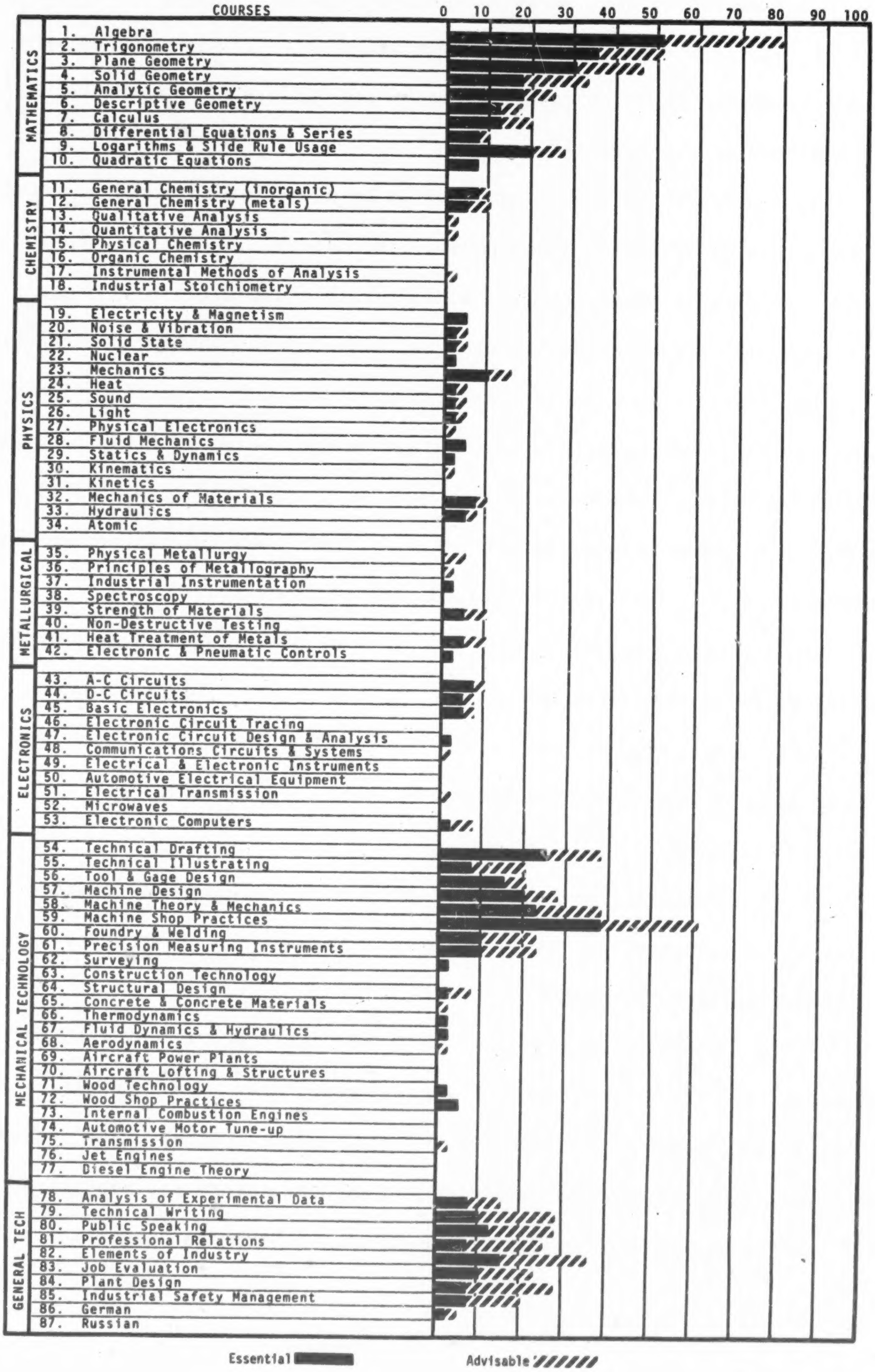
The courses suggested as preferred electives were selections from the general areas of mechanics and general technology. From the area of mechanics, technical illustrating and machine design were suggested. Four selections were suggested from the area of general technology. These were analysis of experimental data, elements of industry, job evaluation, and plant design.

Machine Load Control Planner A total of 39 companies made judgments with regard to the course needs of the Machine Load Control Planner, Figure 104. This was another less complex curriculum, similar to that of the Production Planner and that of the Production Estimator. The only essential course in this curriculum was algebra.

It was considered advisable to have further mathematics training consisting of trigonometry and plane geometry. Also, a mechanics course in machine shop practices was deemed advisable.

A few additional courses were selected from the areas of mathematics, mechanics, and general technology as preferred electives. The mathematics course which came within this classification was solid geometry. The mechanics courses suggested were technical drafting and machine theory and mechanics. From the area of general technology, elements of industry was suggested.

FIGURE 104: MACHINE LOAD CONTROL PLANNER



Cost Analysis Technician The 85 companies which responded to the curricular needs of the Cost Analysis Technician, Figure 105, indicated that this program is regarded as similar to the previous four outlined. Once again, the only course considered as essential was algebra.

Most of the courses regarded as advisable were selected from the area of mathematics. These included trigonometry, plane geometry, and logarithms and slide rule usage. The additional advisable courses were machine shop practices from the area of mechanics and elements of industry from the area of general technology.

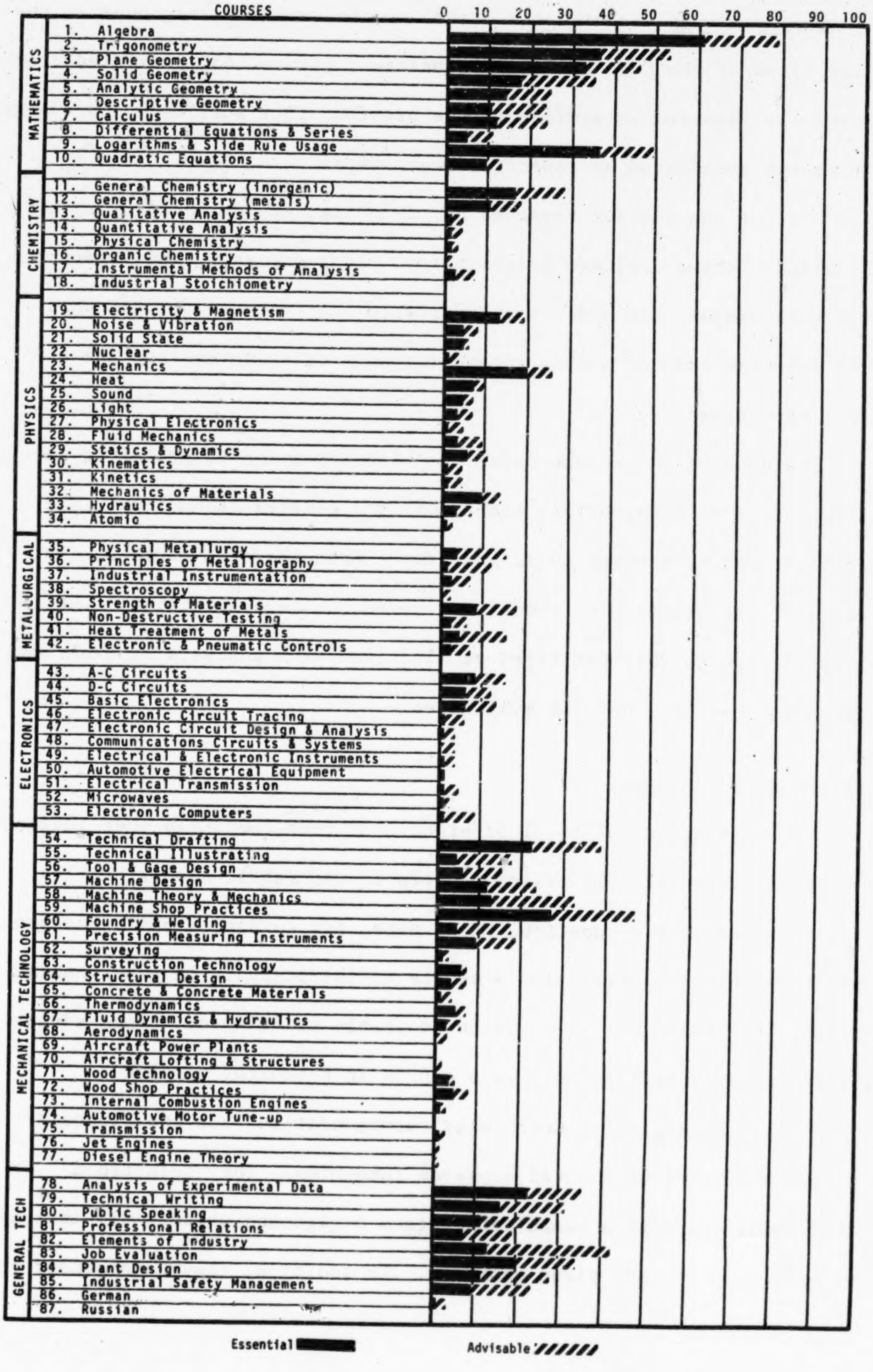
The courses which came under the classification of preferred electives were selections from mathematics, mechanics, and general technology. The mathematics course chosen was solid geometry. From the area of mechanics, technical drafting and machine theory and mechanics were suggested. The general technology courses preferred as electives were analysis of experimental data, technical writing, and job evaluation.

(Miscellaneous Technology)

Fabric Analyst A total of eight different companies made judgments with regard to the curricular training needs of the Fabric Analyst. They indicated that for this occupation, it is necessary to have a basic background in mathematics and chemistry, plus a course in the analysis of experimental data. In addition, they felt that it would be advisable to have additional advanced instruction in chemistry, as well as a course in technical writing.

Viscosity Analyst Curricular recommendations for the Viscosity Analyst were submitted by a total of seven companies. They selected a curriculum requiring only a basic mathematics background which would include algebra, trigonometry, and plane geometry. In addition, they recommended that

FIGURE 105: COST ANALYSIS TECHNICIAN



general chemistry (inorganic) and a course in the analysis of experimental data be included.

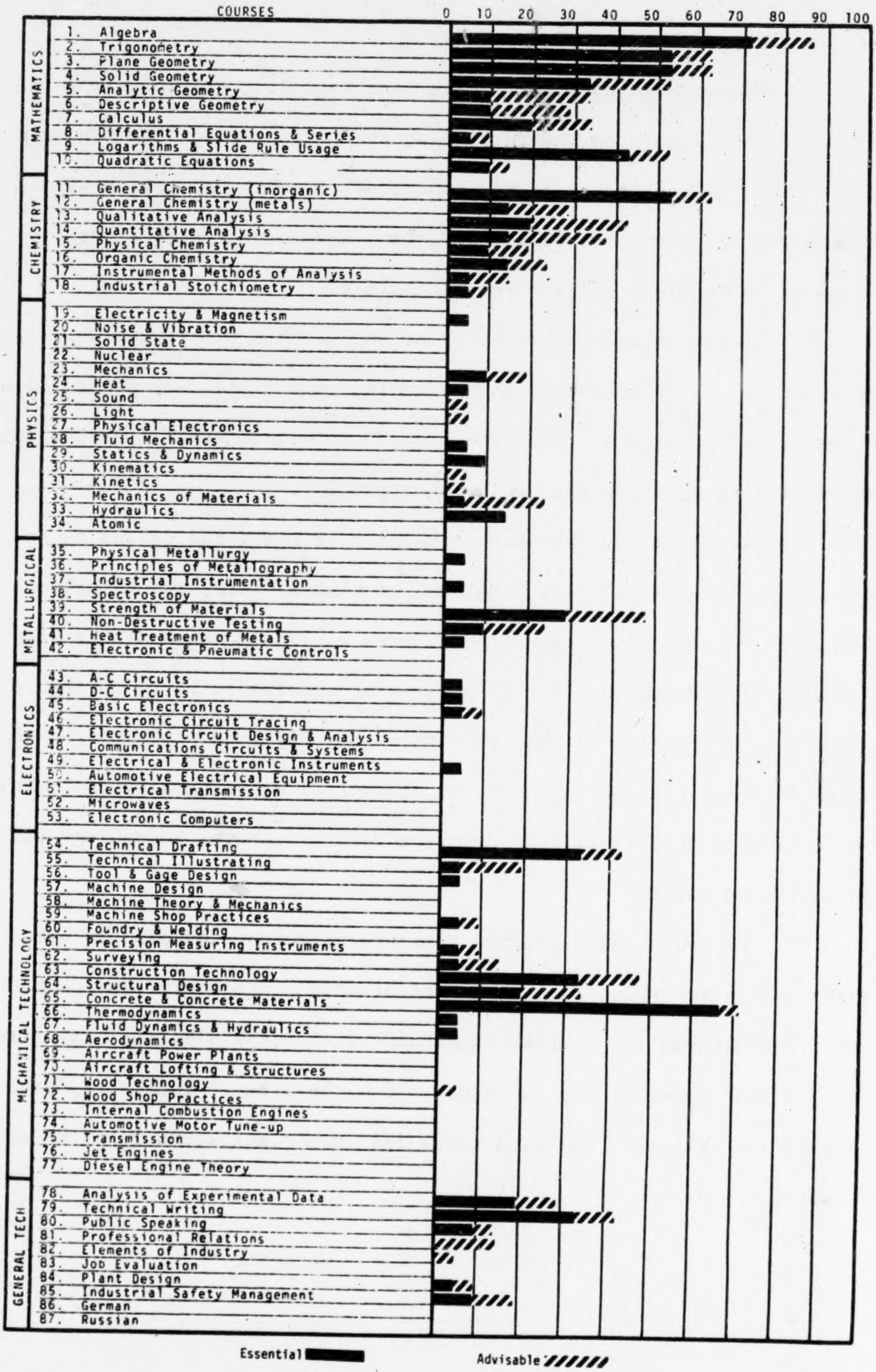
Concrete Technician There were some 21 different companies which responded with regard to the curricular training needs of the Concrete Technician, Figure 106. The needs which they expressed for this occupation were a basic mathematics and chemistry background, plus some course selections from the areas of metals, mechanics, and general technology.

The essential mathematics courses in this curriculum were algebra, trigonometry, plane geometry, and logarithms and slide rule usage. General chemistry (inorganic) was also considered to be an essential, along with mechanics instruction in concrete and concrete materials.

The additional advisable course work consisted of one or two selections from each of the areas of mathematics, chemistry, metals, mechanics, and general technology. Solid geometry was considered advisable, as was chemistry instruction in qualitative analysis. The metals course considered to be advisable was strength of materials. It was felt that two additional courses should be included from the area of mechanics: technical drafting and construction technology. Technical writing from the area of general technology was also considered advisable.

The preferred electives were selected from the primary areas of concentration for this occupation: mathematics, chemistry, and mechanics. First, the mathematics courses which came within the elective classification were analytic geometry and calculus. From the area of chemistry, qualitative analysis was selected, and structural design was suggested from the area of mechanics.

FIGURE 106: CONCRETE TECHNICIAN



CHAPTER IV

ADJUNCT TO TECHNICAL SURVEY

Purpose and Procedure

One of the important findings obtained in this survey was the adverse relationship between company size and the number of technicians reported per engineer. While the largest companies reported having many more engineers than technicians, the smallest companies reported having many more technicians than engineers. This relationship is displayed in Figure 47, and it can also be seen in Figure 44. The responses to this questionnaire did not provide a clear indication as to why this relationship should exist. It was felt that this matter was significant enough to warrant further study; thus an additional investigation was made as an adjunct to the technical survey and the results are reported in this chapter.

A letter was sent to 30 of the survey companies, asking them to provide further information. This letter, which appears in Appendix B, contained three hypotheses which stated possible reasons for the relationship in question. The companies were asked to respond concerning the validity of each hypothesis. They were also asked to explain any additional reasons which they believed to be valid. A total of 17 companies responded to the letter. Five of these were large companies with 5,000 or more employees. Eight were intermediate size companies with employment in the 300's, and four were small companies with employment in the 70's.

Results

Hypothesis A

> The larger companies can afford more highly trained personnel than the smaller companies.

Most of the responding companies agreed that Hypothesis A represented a valid reason for the inverse relationship between the number of technicians reported per company and company size, with only one company disagreeing. This hypothesis was most generally accepted by the respondents.

Hypothesis B

> The problems of the smaller companies do not generally require engineering services and can usually be handled by the technician. Conversely, the problems of the very large companies are generally too complex to be handled by technicians.

The responses indicated that there were mixed feelings with regard to the validity of Hypothesis B. The companies elaborating on this were in general agreement, however, that the smaller companies did need engineering services, but not on a constant basis. It was, therefore, not generally necessary for them to maintain a full-time staff of engineers. Rather, they would contract with outside firms for such services. In this respect, the responses related back to Hypothesis A that the larger companies can better afford a staff of engineers, while the smaller companies "make do" with technicians as much as possible.

Hypothesis C

> The kind (rather than amount) of training given to the technician is particularly suitable for the smaller company, and engineering training is particularly suited to the needs of the larger company.

Most of the responding companies disagreed with Hypothesis C, but a few felt that this hypothesis had some validity. It was generally agreed that engineering training was applicable for companies of all sizes. However, a few of the companies felt that engineers were primarily specialists and that technicians better fit the smaller company's requirement for personnel who could "fill a need in many areas."

Additional Reasons

The respondents were asked to identify any other reasons they felt were responsible for the relationship in question. One of the additional reasons submitted was that management in smaller companies often does not recognize the need for highly trained personnel. Of importance because of the number of companies which referred to it is the statement that larger companies were likely to have engineers "doing jobs that could be handled by technicians." The reason most commonly offered is that the larger companies wishing to obtain contracts from the government and from private industry must "be in a position to sell their capability which, for many programs, is people and their training;" also the larger companies need engineers for establishment and maintenance of their public image. Finally, large companies hire engineers for technician's work because they are "more interested in having a continual flow of young college graduate technical employees who are readily available for promotion up through the various positions in the organization. Therefore, it is more desirable to hire the graduate level engineer as opposed to technicians who may have limited potential for promotion."

Conclusions

In conclusion, it would appear that there are primarily two reasons for the inverse relationship between company size and the number of technicians and/or engineers. The first is economic. The larger companies are more likely to have a continuous demand for engineering services and are more likely to be able to afford highly trained personnel, than are the smaller companies.

The second reason is that the larger companies are more likely to hire engineers to do technician's work for the purpose of obtaining the confidence of their customers. The suggestion that larger companies tend to have a larger proportion of their engineers doing technician's work is not borne out by the findings displayed in Figure 45. However, it has already been suggested that the respondents for the larger companies, being less familiar with the activities of all the company's engineers, might have been more likely to assume that their engineers were serving true engineering functions.

CHAPTER V

CONCLUSIONS AND OBSERVATIONS

The observations that follow are essentially the result of industry's responses to an inquiry regarding its views with reference to the character and content of technology in an industrial setting. An effort is made here to extract from this study general observations regarding the human element in industrial technology and the industrial needs and demands made of that human element. The study attempted to provide the educational and industrial communities with an accurate and organized source of information on manpower educational needs, including data from which possible long-range and reliable planning may be done. The study had a number of variables and suggested many more. It identified a number of doors that need to be opened with reference to the future. It is hoped that this study will assist in providing a factual basis upon which future projections may be made and vanguard needs may be identified.

Industry, at the very center of the world of work, provides a setting for technological development. The educational community, as one of the unique cultural carriers, interpreters, and providers of technological techniques, is influenced by the rapidly moving frontier of science application in a technological setting. Industry with its needs is one of the major sources from which technology derives its content.

Conclusions

Technicians and Engineers

In this study, industry reported an average of slightly more than 52 engineers per company. This number includes engineers who are licensed or possess one or more degrees in engineering. A few very large companies had an inflationary effect upon the computed average number of engineers per company. While the mean number of engineers is accurate and reflects adequately the average number of engineers per company, the median number, which may be interpreted as typical, was found to be 2-1/2 engineers per company. Industry reported that, of the number of bona fide engineers, 15% were serving a technician's function.

Because of the very large differences in company size in American industry today, it is well for those concerned with industrial size to be alert to concepts of averageness and typicalness. American industry is comprised of many small or typical companies, but few of the large or average-sized organizations. The totality of industry cannot be characterized completely by the concepts of "averageness" or "typicalness." While the American industry consists of more small companies (150 employees or less) than large companies, the latter account for an unusually large proportion of the total industrial employment. The average company employs approximately 840 persons, including what industry classifies as 52 engineers and 29 technicians.

Industry acknowledged that from 4% to 6% of its technicians were serving an engineering function. This cross-over of responsibilities suggests a greater need for technological know-how, which in the historical past, was the province of the engineer, but is now the responsibility of the technician, or to coin a concept, the "technologist." There is evidence of the practice of up-titling technicians to engineering status, as well as the semantic problem of the technological-engineering function. Yet, it must be kept in mind that the relationship between engineers and technicians is especially interdependent and mutually supportive.

Education and Training

Currently, approximately 50% of the technicians have had as much as two years of college preparation, with a few technicians having less than high school preparation or education beyond the baccalaureate degree. Most of today's technicians are high school graduates, and more than one-third have at least two years of college preparation. An organized educational approach is seen as one of the more satisfactory answers to the contemporary need for well-qualified technicians.

The program most frequently selected as most satisfactory was the four-year university program with technical trainee programs. Other sources of training included the program which produced experienced technicians from other companies. This was the second preference, with two-year public and private technical schools as the third preference. The technical high school ranked fourth in industrial preference for training programs.

At the present time, higher education programs supply only 16.9% of the personnel serving a technological function. Almost half of all technicians obtained by industry were acquired from within industry, that is, other companies. The tug-of-war within industry for technicians of ability has achieved serious proportions. It was not possible to identify in detail the nature of the preparation received by those technicians acquired from other companies. Of interest, however, and perhaps significant, is that their desirability was due not only to being a convenient source, but of more importance is the experiential preparation provided by industry. Inasmuch as industry places a high priority on actual training experience, this would support the inclusion of industrial internship in a program of higher education.

Industry has had only modest success with in-plant and in-service training programs. In-plant training utilizes primarily the training resources within the company structure, whereas in-service training programs utilize training resources not only within the company structure but also the other educational resources, such as public and private educational institutions, professional seminars, and the like. An interesting relationship between company training programs and hiring practices is that companies with in-plant training programs hired twice as many technicians as those without in-plant training programs. Furthermore, companies with in-service training programs hired nine times as many technicians as those without in-service training programs. It is entirely possible that, in addition to the need reflected in this action, is the positive attitude of industry toward continuing higher education and the desire and need for technological improvement. Those companies with in-service training programs obtained four times as many technicians in the last two years as did companies with only in-plant training programs.

There is a significant preference held by industry for programs of general technical training, as opposed to programs with specific technical training. Companies which preferred general technical training required their technicians to perform a relatively wide range of duties; or when the occasion required, specific training was provided by these companies. On the other hand, those companies which preferred specific technical training usually required relatively repetitious duties within a limited technical area.

An extremely large proportion of industrial concerns, 83%, regard training as important, whether it be general or specific.

Need for Technicians

The need for technicians will increase approximately 50% within the next five years, over that number of technicians which sufficed for industrial requirements for the last 25 years. For every two technicians now employed, three technicians will be needed in the next five years. At least one-fifth of these technicians will be required to have at least a baccalaureate or higher preparation. Currently, less than 10% of the technicians employed were reported as having as much as four years of college. It is estimated that the need for technicians with at least a bachelor's degree will double, if not more than double, in the next five years.

Concern was expressed by industry over those persons currently being prepared for the contemporary technological scene in industry. Expressive of views held by many was the following: "This survey touches on one of the most critical problems in industry today. There are ample programs to train engineers; the prestige of the engineering profession draws candidates." Also observed repeatedly was: "Most technically trained personnel . . . although generally well-versed in the 'classic' methods of design, control, and analysis . . . are woefully lacking in knowledge and [skill required] for up-to-date equipment and the 'know-how' to perform [required] functions." "With new equipment becoming more complicated, automated, and 'technical,' it is absolutely necessary to have more technically trained [personnel]." The most frequently recurring observation is summarized by the following quotation: "We have been using a higher percentage of technicians . . ., we will continue this trend, particularly if people have more training to increase the responsibilities to which they can be assigned."

Over 40% of the technicians required in the next five years will be in the area of electrical and electronics technology, resulting in about 4-1/2 electrical/electronic technicians per company. About 30% of the technicians required in the next five years are in the area of mechanical technology; that is, about three mechanical technicians per company. About 10% of the technicians required in the next five years are needed in the area of metals, chemical, and similar technologies; that is, about one technician per company. General industrial engineering was viewed in a technological setting providing services in quality and production control, methods and time study, supervision, industrial training, industrial safety, drafting and design, machine tool programming, and others.

There is a small number of companies that resolve their technological needs through the use of consultant service provided by distributors of materials and equipment, or use of consulting firms on a contract basis. A much larger group of companies prefer to have their own technological staff, but find it extremely difficult to obtain qualified technical personnel. Technological personnel needs will accelerate markedly in the coming years, even beyond the expected needs currently expressed by industry.

Because of the rather complete and comprehensive preparation that is expected of the prepared technician today, he has extreme occupational mobility into other areas of industry; for example, sales, engineering, industrial engineering, middle and upper management, industrial design, and others.

There appears to be a high correlation currently between the number of production employees and the required number of engineers and technologically competent personnel. This will likely change in the next decade with greater need for the "technologist"--an individual who is likely to be an applied scientist in an industrial setting. In the future, machine tool programming and other forms of automated production will likely decrease the need for the "production worker" as he is currently classified, and increase the need for the technician and technologist in industry. Computerized and programmed production, including evaluative feed-back, is already in common practice. The competitive posture of industry will be in large measure contingent upon a company's ability to obtain prepared personnel capable of implementing contemporary technology. Similarly, the opportunities available to young men and women are directly proportionate to their ability to relate themselves to the technological and behavioral differences and/or advancements of the work world in the future.

Technicians are difficult to obtain and retain. While industry prefers to hire technological personnel from university sources, the current limited number available from the university source obliges industry to resort to a form of industrial cannibalism.

It is most likely that industry can anticipate a requirement of at least 3-1/2 technicians per company within the next five years. If one reflects upon the projected need by American industry, one may make the assumption that such a requirement is a rather modest and limited figure. The actual need may exceed the figure of 3-1/2 technicians per company in the near future. The area of greatest need indicated was in electrical/electronic technology. This occurred in every geographical zone except Illinois and the Mid-Atlantic states, where there was a greater need for mechanical technicians. This need for mechanical technicians was predominant in Illinois perhaps due to the heavy concentration of the machine-tool industry in the Midwest and especially in the state of Illinois. In general, companies with fewer than 300 employees anticipated a need for more additional technicians in the next five years than the number of technicians which they currently employ. Companies with more than 300 employees anticipated a need of fewer additional technicians than they currently employ. When this observation is viewed in the light of a "typical industry" in this country as being a small company, rather than the large industrial giant, one can appreciate the magnitude of the need for technicians within the foreseeable future.

Advancement of technicians, both vertically and horizontally, has also contributed adversely to the supply of qualified technological personnel. The ever-present need of management personnel, technologically knowledgeable, is another significant drain on qualified technicians. Technological know-how has become increasingly important at all levels of responsibility in industry. The practice of removing technicians "off the top" merely aggravates what is already a desperate situation of technological need. This has led to practices that are not always best suited to the situation at hand, such as up-titling marginally qualified personnel capable of limited responsibilities, as well as employing people for whom there is a limited scope of work as well as advancement. Undesirable as it may seem, certain companies offer only limited training in order that "we are not so apt to lose our technicians to other companies." Clearly, a need exists for a greater concern in evolving a cooperative effort between industry and education, to provide sufficient opportunities for adequate preparation for our people in sufficient numbers to meet the needs of industry.

Lest these observations be viewed passively, the economic well-being of many areas of the country will be influenced largely by the manner in which this dilemma is resolved. Young people must also have the opportunity to achieve occupational status and success in a new kind of work world, unknown to many people three decades ago. Failure to provide adequate educational opportunities for our young people will result only in a harvest of sociological problems that will, by comparison, dwarf current segregation problems.

Sources for Technicians

With the exception of New York and New Jersey, the four-year university technology program was most frequently ranked highest in preference as a source of acceptable technicians. In New York and New Jersey, other companies in industry received the most first rankings. It is likely that this is due in part to the fact that some states on the northeastern seaboard have a history of successful two-year post-high school technical programs and that the graduates of these programs find their way into industry. The maturing effect of industrial experience provides an additional sophistication, thus making other companies a most desirable source for producing satisfactory technicians. A relatively large percentage of the technicians required in the South were from technical post-high schools. In the Far West, technicians are acquired from universities with technical trainee programs. In the Mid-Atlantic states, technicians are obtained largely from high school graduates who are given industrial training in an industrial setting. In the Midwest, companies acquire their technicians equally from three different sources: the two-year private technical school, the two-year public technical school, and the four-year university. While industry as a whole prefers the four-year university program graduate, California leads as being the most fortunate in obtaining almost one-fourth of their technicians from the university source. Illinois followed with one-fifth of the technicians coming from a university source. Texas, New York and New Jersey, and the Mid-Atlantic states were able to obtain approximately one-tenth of their technicians from a university source, with New England obtaining only one-twentieth of their technicians from this preferred source. While the educational establishments, both public and private, two-year and four-year, are unable to meet the need for technicians required by industry, industry as a whole is doing little to help itself in the way of in-plant training programs where they assume the total responsibility for the educational effort.

Companies having in-service training programs varied from 8% in the South, 14% in Illinois and California, to 20% on the Eastern Seaboard. In-service programs are characterized as drawing upon not only industrial intellectual resources but others, such as educational institutions, as well. It may be observed that the over-all training policy in industry is substantially the same, whether the training takes place within the corporate structure, or avails itself of outside educational resources. It is also possible that program imitation within industry is a highly developed practice.

Larger companies tended to rank two-year technical schools and four-year universities especially high with reference to preferences for programs, thus expressing a particular awareness of these programs as producing satisfactory technicians. While in general it may be said that industry as a whole prefers general technical training, rather than specific technical training, no clear relationship appears to exist between company size and such preferences. Companies that employ a thousand or more people hire a relatively large percentage of their technicians from four-year universities that have technical training programs. The smaller the company, the greater was the percentage and the chance of the company's so-called engineers serving a technician's function, and likewise, of their technicians serving an engineering function. From this and other information, it may be concluded that, in the larger company, there is greater likelihood that the technological personnel serves functions consistent with assigned titles.

Companies employing up to 100 persons, generally tended to have more technicians than engineers. Companies with 100 to 500 employees generally had about an equal number of technicians and engineers. Companies with more than 500 employees generally tended to have more engineers than technicians. In general, it may be said that the percentage of technicians with two years of college training increased with the increasing size of the company. Conversely, the percentage of technicians with four years of college training tended to decrease slightly as company size increased.

Curricular Conclusions

The industrial sample indicated that almost one-fifth of the technicians to be hired in the next five years should have at least a baccalaureate degree. This requirement was about the same for companies in each of the different employment categories. Companies which prefer general technical training most frequently ranked four-year universities with general technical trainee programs as the most satisfactory type of training. These same companies likewise emphasize formal training and education, while those which preferred specific technical training emphasized industrial skill and experience. In general, nine-tenths of the sampling felt that training and preparation, as well as education, were very important.

There was a consistent pattern of differences with reference to the specificity of education for technicians.

Those desiring general technical training most frequently preferred the four-year university graduate with general technical training programs, hired more technicians from universities, indicated that a larger percentage of their future technicians would possess a bachelor's degree, and ranked their own in-service programs relatively high. They often recruited individuals with a broad technical background and provided the specifics within the training structure of their own in-plant programs. Formal education and training were held to have a priority.

Companies which preferred specific technical training most frequently preferred other companies as a source for providing the most satisfactory technicians. Relatively large percentages of technicians were also obtained from two-year technical schools. Preferences included an emphasis on industrial experience with specific kinds of equipment as well as products.

The most general curricular conclusion to be drawn from the responses made by industry is that mathematics should be emphasized in all areas of technology. The majority of the technical occupations in industry today require a functional knowledge of algebra, trigonometry, and geometry. Capability in logarithms and the use of the slide rule were strongly advised. Many industries indicated that knowledgeability in advanced geometry and some calculus was needed.

In addition to the necessary preparation in the basic and applied sciences and mathematics, there is a need for preparation in verbal and written English, thought structure, and the humanities.

A summary of the broad curricular views held by industry follows; that is, views held in the general areas of chemical technology, metals technology, electronic technology, and mechanical technology.

Chemical Technology

Less emphasis was given to mathematics in the general area of chemical technology than for other occupations; however, with reference to the subject matter areas, mathematics still ranks second in importance to the general field of chemical technology. Algebra, logarithms, and slide rule usage were considered essential; and trigonometry and plane geometry were strongly advised. As might be expected, strong emphasis was placed upon chemistry, the basic subject matter. General chemistry, qualitative analysis, quantitative analysis, and organic chemistry were deemed essential. Physical chemistry, instrumental methods of analysis, analysis of experimental data, and technical writing were viewed as advisable.

Metals Technology

Preparation of a technician in the field of metals technology should include a strong mathematics background. Algebra, trigonometry, and plane geometry were deemed essential by industry. Solid geometry and logarithms were viewed as being advisable. Interestingly, industry feels that general chemistry (inorganic and metals) is essential, and that qualitative analysis, quantitative analysis, physical chemistry, and instrumental methods of analysis, as well as physics of mechanics, mechanics of materials, and the study of heat, were advisable. Other courses noted by industry as essential were physical metallurgy, principles of metallography, industrial instrumentation, strength of materials, non-destructive testing, heat treatment of metals, and the analysis of experimental data. In addition, industry viewed as advisable, preparation courses in spectroscopy, technical drafting, and technical writing. Knowledgeability of the sciences and mathematics can be viewed here as being of equal importance to the skills necessary for one to function effectively in metals technology.

Electronic Technology

The functional needs of those in the area of electronic technology varied widely. In general, use of algebra, trigonometry, plane geometry, logarithms and the slide rule were deemed essential, while solid geometry was viewed by industry as advisable. In the area of physics, electricity and magnetism were viewed as essential, while industry deemed the subject of mechanics as advisable. Courses in AC circuits, DC circuits, basic electronics, electronic circuit tracing, electrical and electronic instrumentation, communications circuits and systems, and technical drafting were viewed as being essential. Similar to other areas of technology, industry felt that the ability to analyze experimental data, and to express this analysis in the form of technical writing, bordered on the advisable.

Mechanical Technology

Industry viewed course work in mathematics as essential in the area of mechanical technology; i.e., algebra, trigonometry, and plane geometry. Industry viewed solid geometry, logarithms and slide rule usage as strongly advisable, and analytic geometry as advisable. In the area of physics, mechanics was deemed advisable. Technical drafting and machine shop practices were viewed as essential. Tool and gauge design, machine design, and machine theory and mechanics were viewed as advisable. Special note is made here of the fact that the area of mathematics was viewed as important as any phase of mechanical technology, including the mechanical areas specifically. Industry apparently views mathematical concepts, skills, and the ability to articulate these concepts operationally in a technological setting as very important.

Miscellaneous Technology

A final section of the study included an area known as "miscellaneous technology," which provided for industrial responses not appropriately included under the previously mentioned major areas of technology. While the number of industrial responses were by comparison relatively small, when viewed in the setting of the other major areas of the study, it was felt that a general statement and treatment here is warranted.

Approximately 50% of the responses to this aspect of the study could be identified under an emerging concept of industrial engineering. In general, it can be observed that the concept of industrial engineering, in addition to requiring a substantial amount of mathematics in the areas of algebra, trigonometry, plane geometry, solid geometry, and analytical geometry, appeared to have a general need for a comprehensive exposure to the areas of chemistry, physics, metallurgy, electronics, mechanical technology, and general technology. Inferentially, from comments made by industry, such subjects as quality control, machine tool programming, industrial personnel management, industrial training, supervision, and industrial safety are important concerns to the industrial engineer. For specific curricular recommendations, the reader is referred to the chapter on Technical Training Analysis.

Concluding Observations

Sweeping changes are taking place in American industry at an ever-accelerating pace. The impact of rapid scientific and technological progress has been twofold. Both the quantity and the quality of the technological exposure are of urgent concern. The nature of these changes is such that the quantity of needed technological involvement is increasing rapidly. Also, a number of traditional skills, as well as occupations, are becoming obsolete, with needed new areas of work being created for the technologically oriented. The quality needed for adequate involvement is also changing. The devices and processes, of an increasingly complex industry are being continually up-dated or completely replaced, often by more complex instrumentation and sophisticated techniques which require a greater degree of technological knowledgeability and skills.

A new and more adequate level of industrial-educational dialogue is urgently needed. The technology which man is creating is unique because it has no boundaries. Content is not static, but is principally related to process rather than product--a universalism of the industrial process. Industry and the technologies have developed a level of sophistication to a point where they are now able to share, from within the internal disciplines, providing patterns of interdependence and the potential for greater growth.

The current era of technology (for the most part, a new content area born out of the scientific requirements of industry during and since World War II) is now influencing the fundamental processes of industry. These processes contain essentially the human equation in a social-industrial setting. As has often been suggested, technology in its various forms is the extension of man and his various capabilities. It is enabling man to utilize his intellectual and physical resources more effectively, making it possible to extricate himself from the morass of detailed processes, and providing more opportunity for him to deal with the larger generalities more important to the total industrial-technological picture. Hence, far from de-emphasizing the individual, man has now more opportunity for greater freedom of personal involvement. In the use and projection of knowledge, man, using technology, is able to simulate ideas without the necessity of total commitment of himself and his resources. He should be able to extend himself similarly by associating and sharing himself within the broader spectrum of technology; thus enhancing his own potential, as well as the society of which he is a part.

So dynamic is this developmental process that it has produced a series of technological revolutions. One is the chemical revolution occurring and affecting the very material foundations of industry. A second revolution has taken place in the area of standards and specifications as criteria for the selection of better materials, methods, processes, and products.

Only a few years ago, symbolic numerical control and machine tool programming were developmental curiosities. Today, they are an historical fact. The impelling integration of men and machines, of ideas and of industrial procedures, has been viewed as something creative, dynamic, threatening, perplexing, and revolutionary. The mysteries of the industrial-scientific innovations can be unfolded only through a sincere dialogue between industry, technology, and education.

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BIBLIOGRAPHY

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APPENDIX A

NORTHERN ILLINOIS UNIVERSITY

DeKalb, Illinois

April, 1964

Department of
Industry and Technology

Dear Sir:

Northern Illinois University is endeavoring to identify the technological needs of industry. Your company's needs represent an important part of the total technological concern of industry. Therefore, we consider receiving a response from you to be a valuable contribution to this study.

As you know, there is a good deal of concern held by industry and educators alike about technology and the technician. To fulfill the needs of industry and render an educational service to young people, it is essential to pinpoint the specific areas of greatest need. We are trying to determine not only the number of technicians needed by industry but also the specific type of technician and talents he is expected to possess.

To answer this questionnaire will take about one hour of your time. Where the responses require technical insight and knowledge, we would appreciate it if you would consult a functioning technician. Ultimately we hope this will provide you as an employer with more and better qualified technical personnel.

Your responses will be treated in a confidential manner. Results will be reported as statistical summaries and your identity will not be revealed in any way. The number that appears on the enclosed questionnaire is for mailing purposes in order that we will not be obliged to contact you later if you have already returned your questionnaire. Therefore, we hope you will respond freely and openly.

Permit me to thank you for your time and attention given to this questionnaire.

Sincerely yours,

Eckhart A. Jacobsen

Eckhart A. Jacobsen, Head
Department of Industry and Technology

EAJ:ss
Enc.

Department of Industry and Technology
College of Fine and Applied Arts
Northern Illinois University

SURVEY OF
THE TECHNICAL NEEDS OF INDUSTRY

Please read the following definitions so that the terms "Engineer" and "Technician" are used with the same meaning by all responding to this survey.

The Engineer's Function

Those services dealing with consulting activities and the translation and application of science and mathematics to the technological problems in industry. These activities may be characterized as interpreting scientific content for practical usage.

The Technician's Function

Those activities dealing with the implementation of the engineering function into industrial reality. This would require a substantial degree of proficiency in the fields of mathematics and science and a familiarity with the potentials of industrial processes. The technician's work role is either one of liaison between engineering and production or one of evaluating the control function of production.

Note: Where actual records are not available, please estimate the answer to the question

1. Check the following industrial classifications that are of primary and major concern to your company locally: (Check all that apply)

1. ________ Food and Kindred Products (including supervision of company food services)
2. ________ Paper, Wood and Allied Products
3. ________ Chemicals and Allied Products
4. ________ Petroleum Products and Extraction
5. ________ Stone, Clay and Glass Products
6. ________ Primary Metal Industries
7. ________ Fabricated-Metal Products and Ordinance
8. ________ Textile Mill Products and Apparel
9. ________ Machinery
10. ________ Electrical-Electronic Equipment
11. ________ Motor Vehicles and Equipment
12. ________ Professional and Scientific Instruments
13. ________ Communications
14. ________ Others (identify) ______________________________

____

____

Do Not Write In This Column

________ Col. 1-5
________ Col. 6-10
___01___ Col. 11-12

1. ________ Col. 13
2. ________ Col. 14
3. ________ Col. 15
4. ________ Col. 16
5. ________ Col. 17
6. ________ Col. 18
7. ________ Col. 19
8. ________ Col. 20
9. ________ Col. 21
10. ________ Col. 22
11. ________ Col. 23
12. ________ Col. 24
13. ________ Col. 25
14. ________ Col. 26
________ Col. 27
________ Col. 28
________ Col. 29
________ Col. 30

Do Not Write In This Column

2. What is the basic organization of your company? (check one)

(Check one) (Basic organization)

1. ________ local
2. ________ regional (several states)
3. ________ national (all states)
4. ________ international

________ Col. 31

3. What was the approximate gross dollar value of your industrial product during the past business year in your local plant? (Check one)

(Check one) (Gross dollar value)

1. ________ $0 - 200,000
2. ________ 200,000 - 500,000
3. ________ 500,000 - 1 million
4. ________ 1 million - 2 million
5. ________ 2 million - 5 million
6. ________ 5 million - 10 million
7. ________ 10 million - 20 million
8. ________ 20 million - 50 million
9. ________ 50 million and over

________ Col. 32

4. What is the total number of people employed by your company locally?

(Year) (No. of people)

1. 1950 ________________
2. 1955 ________________
3. 1964 ________________
4. 1966 ________________ (estimated)

1. ________ Col. 33
2. ________ Col. 34
3. ________ Col. 35
4. ________ Col. 36

5. What is the total number of workers involved directly in production (fabricating, assembly line, packaging, etc.) employed by your company locally?

(Year) (No. production workers)

1. 1950 ________________
2. 1955 ________________
3. 1964 ________________
4. 1966 ________________ (estimated)

1. ________ Col. 37
2. ________ Col. 38
3. ________ Col. 39
4. ________ Col. 40

	Do Not Write In This Column
6. What is the total number of engineers (licensed or possessing a Bachelor of Engineering degree or more) employed by your company locally?	
(Year) (No. engineers)	
1. 1950 ____________	1. ________ Col. 41-43
2. 1955 ____________	2. ________ Col. 44-46
3. 1964 ____________	3. ________ Col. 47-49
7. At present in your local company, how many of your total engineering force are serving a true engineering function as defined on page one?	
(No. engineers) (Time in engineering function)	
1. ________ Part time	1. ________ Col. 50-52
2. ________ Full time	2. ________ Col. 53-55
8. At present, how many of your engineers (possessing a Bachelor of Engineering degree or more) are serving a technicians function as defined on page one?	
(No. engineers) (Time in technicians function)	
1. ________ Part time	1. ________ Col. 56-58
2. ________ Full time	2. ________ Col. 59-61
9. At present, what is the total number of technicians currently employed by your local plant, as defined on page one?	
________	________ Col. 62-65
10. At present, in your local company, how many of your technicians (technicians having a high school, or post high school training but not a Bachelor's degree) are serving a true technicians function as defined on page one?	
(No. technicians) (Time in technician's function)	
1. ________ Part time	1. ________ Col. 66-69
2. ________ Full time	2. ________ Col. 70-73
11. At present, in your local company, how many of your technicians are serving a true engineering function as defined on page one?	
(No. technicians) (Time in engineering function)	
1. ________ Part time	1. ________ Col. 74-76
2. ________ Full time	2. ________ Col. 77-79
	End of Card No. 01

Do Not Write In This Column

Card No. 2

______ Col. 1-5
______ Col. 6-10
02 Col. 11-12

12. For this year (1964), what is the number of technicians employed by your local company having the following educational background:

(No. of technicians) (Educational background)
1. ______ less than high school graduation
2. ______ high school graduation
3. ______ high school graduation and 2 years of college
4. ______ 4 years of college or the Bachelor's degree
5. ______ education beyond the bachelor's degree

1. ______ Col. 13-15
2. ______ Col. 16-18
3. ______ Col. 19-21
4. ______ Col. 22-23
5. ______ Col. 24-25

13. Rank the top four technician programs in order of preference (1 best - 4 poorest) which your company feels provides the most satisfactory technicians.

(Rank 1-to 4) (Technical programs)
1. ______ technical high school
2. ______ two year private tech. schools (including junior college)
3. ______ two year public tech. schools (including junior college)
4. ______ four year university with technical trainee programs
5. ______ experienced technicians from other companies
6. ______ your own in-service program
7. ______ other, explain: ______

1. ______ Col. 26
2. ______ Col. 27
3. ______ Col. 28
4. ______ Col. 29
5. ______ Col. 30
6. ______ Col. 31
7. ______ Col. 32
______ Col. 33

14. What is your preference locally, with regard to background training, when hiring technicians? (Check one)

(Check one) (Background training)
1. ______ general technical training
2. ______ specific technical training

Comments: ______

______ Col. 34

15. How many technicians have you acquired within the past two years from the following sources?

(Number) (Sources)
1. ______ two year private tech. schools (including junior college)
2. ______ two year public tech. schools (including junior college)
3. ______ four year university with technical trainee programs
4. ______ experienced technicians from other companies
5. ______ other, explain: ______

1. ______ Col. 35-36
2. ______ Col. 37-38
3. ______ Col. 39-40
4. ______ Col. 41-42
5. ______ Col. 43-44

Do Not Write In This Column

16. Do you have an in-plant training program exclusively for your technicians?
Yes ______ No ______
If yes, how many have you trained in the last 2 years? (Number) ______ | ______ Col. 45-46
If yes, briefly describe this program: ______________________ | ______ Col. 47-48
____
____

17. Do you have an in-service training program for your technicians where you use the facilities of neighboring educational institutions?

Yes ______ No ______ | ______ Col. 49

A. If yes, approximately how many of your employees were involved in this training in the past two years?

(number) ________ | ______ Col. 50-51

18. Approximately how many additional technicians in the areas indicated below, will your company need in 5 years (by 1969)?
A. Technicians having post high school training but less than a Bachelor's degree:

(How many)	(Areas)		
1. ______	Chemical	1. ______	Col. 52-54
2. ______	Metals	2. ______	Col. 55-57
3. ______	Electrical - Electronics	3. ______	Col. 58-60
4. ______	Mechanical	4. ______	Col. 61-62
5. ______	Others (specify) ______________	5. ______	Col. 63-64

____

B. Technicians possessing a Bachelor's degree or more:

(How many)	(Areas)		
1. ______	Chemical	1. ______	Col. 65-67
2. ______	Metals	2. ______	Col. 68-70
3. ______	Electrical - Electronics	3. ______	Col. 71-73
4. ______	Mechanical	4. ______	Col. 74-76
5. ______	Others (specify) ______________	5. ______	Col. 77-80

____

19. On the following pages we ask you to check those courses opposite the occupations which you feel are essential or advisable preparation for the technicians found in your company. In responding use symbols X for Essential and O for Advisable. If the listing does not include technicians employed by your company or courses felt desirable please write them in at the end of the appropriate list and complete the form as previously requested.

If you do not feel qualified to make judgments regarding necessary courses, please seek the assistance of someone in your organization whose background enables him to make these necessary judgments.

SYMBOLS: X–ESSENTIAL
O–ADVISABLE

	COURSES	MATHEMATICS												CHEMISTRY										PHYSICS																				
	OCCUPATIONS	**1.Algebra**	2.Trigonometry	3.Plane Geometry	**4.Solid Geometry**	5.Analytic Geometry	6.Descriptive Geometry	**7.Calculus**	8.Differential Equation & Series	9.Logarithms & Slide Rule Usage	**10.Quadratic Equations**	11.	12.	**13.General Chemistry (inorganic)**	14.General Chemistry (metals)	15.Qualitative Analysis	**16.Quantitative Analysis**	17.Physical Chemistry	18.Organic Chemistry	**19.Instrumental Methods of Analysis**	20.Industrial Stoichiometry	21.	**22.**	**23.Electricity and Magnetism**	24.Noise & Vibration	25.Solid State	**26.Nuclear**	27.Mechanics	28.Heat	**29.Sound**	30.Light	31.Physical Electronics	**32.Fluid Mechanics**	33.Statics & Dynamics	34.Kinematics	**35.Kinetics**	36.Mechanics of Materials	37.Hydraulics	**38.Atomic**	39.	40.	**41.Physical Me**	42.Princi	43.
CHEMICAL TECHNOLOGY	**1.Assistant Chemist**																																											
	2.Ceramics Technician																																											
	3.Chemical Technician, Radiation																																											
	4.Control Analyst																																											
	5.Laboratory Assistant																																											
	6.Research Laboratory Analyst																																											
	7.																																											
	8.																																											
METAL TECHNOLOGY	**9. Assistant Metallurgist**																																											
	10. Laboratory Technician, Foundry																																											
	11. Research Lab Analyst(Extractive metallurgy)																																											
	12. Research Lab Analyst (Physical metallurgy)																																											
	13. Asst. Metallurgist, metal crystallisation																																											
	14.																																											
	15.																																											
ELECTRICAL TECHNOLOGY	16.Electrical test development technician																																											
	17. X-Ray Equipment Development Technician																																											
	18.Design Draftsman, Electrical																																											
	19.Test Technician (Electric motors)																																											
	20.Experimental Technician (Aircraft)																																											
	21.Solenoid Technician																																											
	22.Research Technician, Electronic systems																																											
	23.Electronic Technician, Printed Circuits																																											
	24.Electronic Technician, Multiplexing																																											
	25.Electronic Technician, Telemetering																																											
	26.Electronic Layout Technician																																											
	27.Transducer Development Technician																																											
	28.Test Technician, Guidance systems																																											
	29.Instrumentation Technician, Electronic																																											
	30.Computor Technician																																											
	31.Communications Technician																																											
	32.Sound Technician																																											
	33.																																											
	34.																																											
MECHANICAL TECHNOLOGY	35.Tool Designer																																											
	36.Tool Proofer																																											
	37.Analyst, Gage Designer & Planning																																											
	38.Engineering Drawing Checker																																											
	39.Loftsman																																											
	40.Design Draftsman, Electromechanical																																											
	41.Design Draftsman, Hydraulic Linkage																																											
	42.Design Draftsman, Ram Jet Engine																																											
	43.Design Draftsman, Rocket Engine																																											
	44.Steam Turbine Design Technician																																											
	45.Engine Dev Tech.(Internal Combustion)																																											
	46.Design Draftsman, Machinery																																											
	47.Layout Man and Checker																																											
	48.Design Checker																																											
	49.Die Designer																																											
	50.Engineering Designer Aircraft Structures																																											
	51.Process Description Writer																																											
	52.Production Planner																																											
	53.Production Estimator																																											
	54.Engineering Scheduler																																											
	55.Machine Load Control Planner																																											
	56.Cost Analysis Technician																																											
	57.																																											
	58.																																											
MISC.	59.Fabric Analyst																																											
	60.Viscosity Analyst																																											
	61.Concrete Technician																																											
	62.																																											

TECHNICAL TRAINING ANALYSIS

				METALLURGICAL TECHNOLOGY						ELECTRICITY & ELECTRONICS													MECHANICAL TECHNOLOGY																										GENERAL TECHNOLOGY														
gy	of Metallography	ial Instrumentation	pectroscopy	45.Strength of Materials	46.Non-Destructive Testing	**47.Heat Treatment of Metals**	48.Electronic & Pneumatic Controls	49.	**50.**	**51.A - C Circuits**	52.D - C Circuits	53.Basic Electronics	**54.Electronic Circuit Tracing**	55.Circuit Design & Analysis	56.Communications Circuits Systems	**57.Electrical,Electronic Instruments**	58.Automotive Electrical Equipment	59.Electrical Transmission	**60.Microwaves**	61.Electronic Computers	62.	**63.**	64.Technical Drafting	65.Technical Illustrating	**66.Tool and Gage Design**	67.Machine Design	68.Machine Theory And Mechanics	**69.Machine Shop Practices**	70.Foundry & Welding	71.Precision Measuring Instruments	**72.Surveying**	73.Construction Technology	74.Structural Design	**75.Concrete & Concrete Materials**	76.Thermodynamics	77.Fluid Dynamics & Hydraulics	**78.Aerodynamics**	79.Aircraft Power Plants	**80.Aircraft Lofting & Structures**	81.Wood Technology	82.Wood Shop Practices	**83.Internal Combustion Engines**	84.Automotive Motor Tune-Up	85.Transmission	**86.Jet Engines**	87.Diesel Engine Theory	88.	**89.**	90. Analysis of Experimental Data	91. Technical Writing	**92.Public Speaking**	93.Professional Relations	94.Elements of Industry	**95.Job Evaluation**	96.Plant Design	97.Industrial Safety Management	**98.German**	99.Russian	100.	**101.**	102.	103.	**104.**

20. As it is difficult to examine the total concern for technician preparation in a questionnaire, please write any additional suggestions or concerns below which you may be prompted to make.

Please fold and staple questionnaire together with our address showing (on next page) and mail. No postage is necessary.

Fold on This Line

FIRST CLASS
PERMIT NO. 2
SEC. 34.9, P.L. & R.
DEKALB, ILLINOIS

BUSINESS REPLY MAIL

No Postage Stamp Necessary If Mailed in the United States

---Postage Will Be Paid By---

DEPARTMENT OF INDUSTRY AND TECHNOLOGY
NORTHERN ILLINOIS UNIVERSITY
DEKALB, ILLINOIS

Staple Here

APPENDIX B

NORTHERN ILLINOIS UNIVERSITY

DEKALB, ILLINOIS 60115

Department of
INDUSTRY AND TECHNOLOGY

Area Code 815
Telephone 753-1349

February 5, 1965

Dear Sir:

We are presently engaged in a research project in which your company has already taken part designed to identify the technological needs of industry. The data which we have collected indicate that as the size of a company increases, the number of technicians in the company per engineer tends to decrease considerably. While companies with up to fifty employees reported about twice as many technicians as engineers, companies with one thousand or more employees reported about twice as many engineers as technicians.

We feel that it would be important to know why this relationship exists. Therefore, we have selected a number of companies to answer a few relevant questions. Please complete the enclosed form and mail it in the self-addressed envelope.

Very truly yours,

Eckhart A. Jacobsen, Head
Department of Industry and Technology

NORTHERN ILLINOIS UNIVERSITY
DEKALB, ILLINOIS 60115

Department of
INDUSTRY AND TECHNOLOGY

Area Code 815
Telephone 753-1349

ADJUNCT TO TECHNICAL SURVEY

1. Our data indicate that there is an inverse relationship between company size and number of technicians per engineer. Please state to what extent you feel the following three hypotheses are valid explanations for this relationship.

   A. That the larger companies are able to afford more highly trained personnel than the smaller companies.

   B. That the problems of the smaller companies do not general require engineering services, but can usually be handled by a technician. Conversely, the problems of the very large companies are generally too complex to be handled by technicians.

   C. That the kind (rather than amount) of training given to the techncian is particularly suitable for the smaller company, and engineering training is particularly suited to the needs of the large company.

2. Do you feel that there may be other reasons for this relationship? If so, please explain.

ERRATA SHEET

FOR

A SURVEY OF TECHNICAL NEEDS OF INDUSTRY AND IMPLICATIONS FOR CURRICULUM DEVELOPMENT IN HIGHER EDUCATION - 1966

BY

ECKHART A. JACOBSEN

	Corrections Underscored
Page 6, Par. 1, Line 5	medians, percentages, and correlations
Page 24, Par. 2, Line 2	heterogeneous
Page 35	Content of page 35 should be on page 36.
Page 36	Content of page 36 should be on page 35.
Page 42, Par. 2, Line 4	secured twice as many technicians
Page 43, Par. 1, Line 2	obtained somewhat more technicians
Page 43, Par. 1, Line 7	employed about ten technicians in the last two years from four year universities with technical programs
Page 43, Par. 1, Lines 8 and 9 .	employed an average of one half technician in the same period
Page 44, Par. 3, Line 3	into
Page 86, Figure 54	Percentage omission on chart titled General Technical Training Preference should read 24.3%.
Page 99, Par. 3, Line 1	summary of responses
Page 191, Par. 1, Line 1	was the inverse
Page 198, Par. 2, Line 12	this action, this demonstrates the positive attitude
Page 198, Par. 2, Line 15	technicians in the last two years from four year universities as did companies
Page 209, Par. 2, Line 5	and analytic geometry,